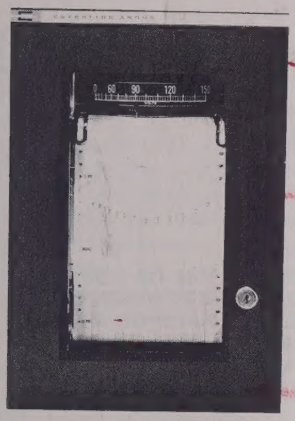
INSTRUCTION MANUAL

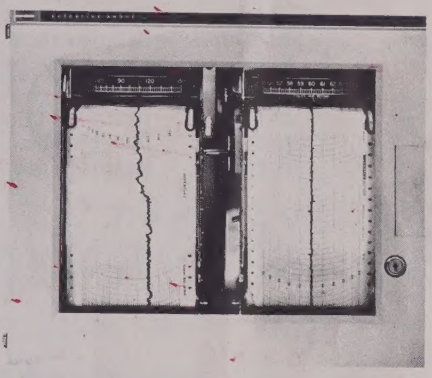
FOR SERIES A ANALOG RECORDER

Serial No. [redacted]

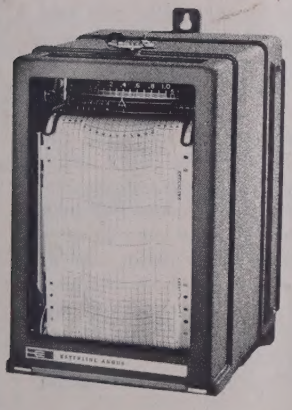
CAL LAB
HARRIS TECHNICAL SERVICES
3888 Calle Fortunada, Ste. A
San Diego, CA 92123



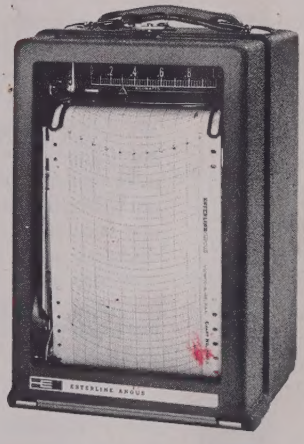
FLUSH MOUNTED



TWIN
(FLUSH CASE ILLUSTRATED)



FRONT MOUNTED



PORTABLE

ESTERLINE ANGUS
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NOTE: FOR A COMPLETE TECHNICAL DESCRIPTION OF YOUR SPECIFIC INSTRUMENT, SEE THE DATA SHEET WHICH IS SUPPLIED WITH THIS MANUAL. SPECIAL DRAWINGS AND SUPPLEMENTARY INSTRUCTIONS THAT MAY BE REQUIRED FOR YOUR RECORDER WILL BE LISTED ON THE DATA SHEET AND WILL BE FOUND IN THE APPENDIX OF THIS MANUAL.

WARRANTY—Only the products manufactured by the Seller and sold hereunder are warranted as free from defects of materials and workmanship and in conformance with specifications. There are no other oral, statutory, or implied warranties. Seller's obligation hereunder shall be and is limited to servicing or replacing f.o.b. its plant in Indianapolis, Indiana or such other point as Seller may designate, or refunding the purchase price of any such product manufactured by the Seller which proves to be defective in material or workmanship or which fails to conform to specifications therefor, provided that (1) written notice of such defect or failure is received by Seller from Purchaser within one year after the date of shipment of such products manufactured by the Seller, and (2) such defects, in the opinion of Seller, shall not have arisen from improper use. The absence of such written notice of defect, or failure, or lack of conformance to specifications within the specified time shall constitute a waiver of any claim. Seller may, after receipt of notice, require purchaser to send said products, transportation prepaid, to Seller for its examination and inspection.

TECHNICAL PUBLICATIONS

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PART A

GENERAL INSTRUCTIONS

SECTION 1 - INTRODUCTION

1.1 SCOPE OF MANUAL

a. This manual covers technical instructions for the installation, operation, and maintainance of your Esterline Angus instrument. The manual is divided into the following separate parts: PART A - contains general information about the instrument and its installation; PART B - contains complete instructions for the chart drive system of the instrument (graphic recorders only); PART C - contains instructions and specifications on the various measuring systems available for the instrument; and PART D - the Appendix, covers optional accessories and attachments plus technical data as required for special instrument modifications.

NOTE: If supplemental instructions in the Appendix conflict with statements in the basic manual, the supplemental data shall be considered authoritative.

b. Do not attempt to operate the instrument until all instructions have been studied. Failure to follow recommended procedures may result in unsatisfactory operation or permanent damage to vital parts of the equipment.

1.2 SUPPLIES AND PARTS

a. For graphic recording instruments, always keep enough Esterline Angus charts on hand to operate each unit for at least one month. If the instrument uses ink, Esterline Angus inks are available in four standard colors--red, green, purple, or black. Red ink will be supplied unless otherwise specified. By purchasing in large quantities, worthwhile savings can be made on these supplies.

b. When ordering replacement or spare parts, always give the instrument serial number as well as the individual part numbers. Refer to the Data Sheet and to the various assembly drawings in this manual for correct part numbers.

SECTION 2 - INSTALLATION

2.1 UNPACKING

a. Since all Esterline Angus instruments are carefully inspected and packed before shipment, carriers are responsible for any damage in transit. Should a packing case appear damaged, make a notation to that effect on the express receipt or freight bill. If the shipment is damaged, notify the carrier and Esterline Angus at once.

b. A packing slip listing all enclosed items is included with each shipment. Check off the items as they are unpacked; if anything is missing, go through the packing material carefully before throwing it away. New instruments are shipped complete with recording supplies and accessories as required for the particular systems ordered. Each instrument having a flush-styled case will also include a set of keys for the door lock.

2.2 INSTALLING CASE

a. The instrument should be mounted upright and approximately level in a clean, well-lighted location for all permanent installations. The internal systems should not be subjected to vibration or extremes of temperature and humidity. If excessive dust, steam, moisture, smoke, or corrosive fumes are present, a protective cabinet should be constructed for the unit. The cabinet must be properly vented, however, to maintain a flow of air through the case when heat producing components are supplied.

b. Instruments should not be positioned close to bus bars or cables carrying large currents due to possible adverse effects of strong magnetic fields; this is especially true for instruments having electrical DC measuring systems.

c. When installing the instrument on a panel, always refer to mounting dimensions. Series resistances, and other accessories, if used, will either be attached to the instrument case or supplied as a separate unit. All separate boxes will be marked with the instrument's serial number; and all resistance boxes must be mounted in a vertical position. Never place a resistance multiplier box in a closed area or obstruct the flow of air through it.

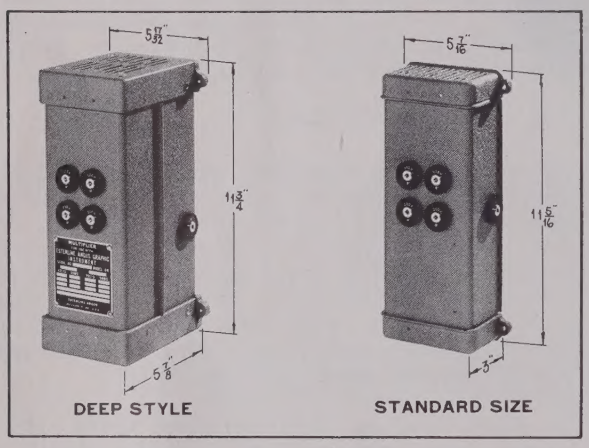


Figure A1. Multiplier Boxes For Attachments.

d. The cases of portable, front switchboard, and wall-type instruments have latches that can be sealed with standard meter seals or locked with a small padlock. On all flush cases, the door is fitted with a flush latch and built-in lock. Two keys are furnished with each instrument and these keys fit any flush-case lock.

NOTE: For case installation of instruments having non-electrical measuring systems, refer also to PART C of this manual.

2.2.1 Portable

A portable model features a carrying handle and removable front cover. The bottom of the portable case has four holes drilled and tapped for No. 10-24 screws to fasten the instrument to any flat surface. Power, if required, is supplied by a line cord at the rear of the case. Input terminals are tapered and threaded to receive either tapered plugs (usually furnished on leads) or binding posts.

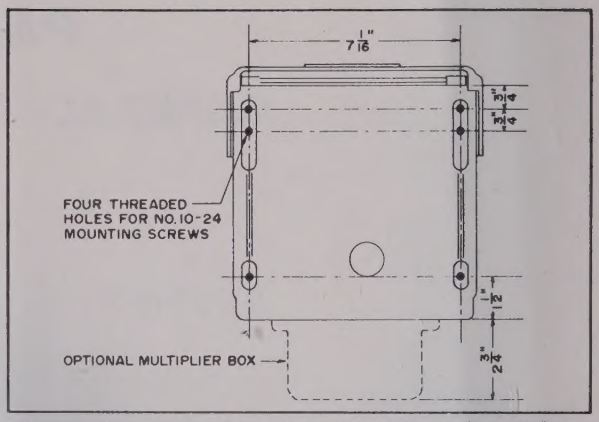


Figure A2. Portable Case Base Mounting Holes.

2.2.2 Flush

a. Each flush case instrument has a hinged door with large viewing window. The flush case body and mounting flange are die cast as a single unit. It can be mounted on panels of almost any thickness. A set of screws are supplied for standard panel mounting. If panel material is thin and of a large area, additional supports may be necessary (consult factory).

b. Twin cases fit standard relay racks with no cutout required. However, a shim may be necessary at the case front for door clearance. See the diagrams in this section for exact cutout and drilling dimensions. All electrical connections are made to terminals at the back of the instrument.

2.2.3 Front Switchboard

Front switchboard instruments have a removable front cover and three rear mounting studs. Mounting hardware is also supplied. Units with electrical measuring systems are calibrated for either insulated or metal mounting surfaces (as specified prior to shipment). Consult mounting dimensional diagrams in this section for either single or twin installations. Electrical connections are made to studs (independent of mounting studs) at the back of the instrument.

2.2.4 Wall

a. Cases designed for hanging on the wall feature a removable front cover and also a mounting and wiring compartment attached to the back of the case. Three mounting lugs are provided on the case, but due to the many installation possibilities, mounting hardware is not supplied.

b. Electrical connections are made to terminals inside the wiring compartment, and removable terminal covers are provided on the

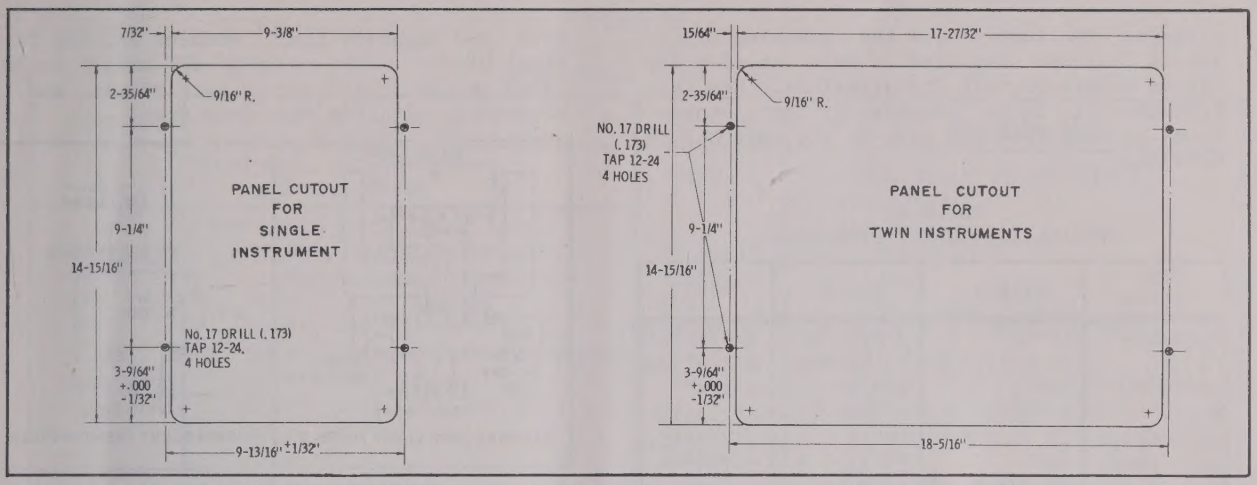


Figure A3. Panel Cutouts and Drilling Dimensions for Flush Cases.

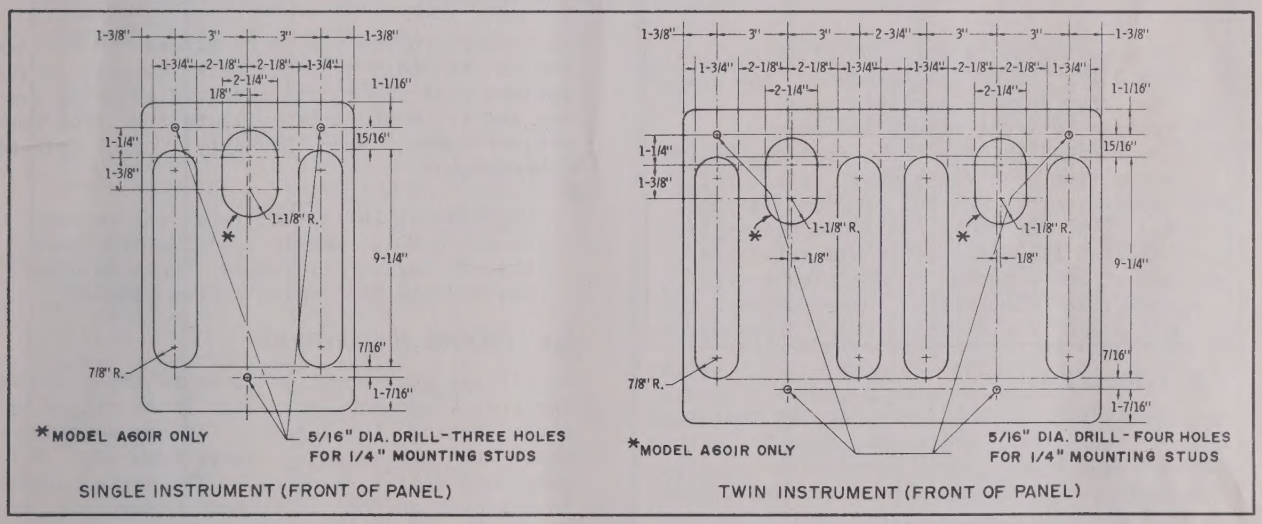


Figure A4. Panel Cutout Templates for Front Switchboard Cases.

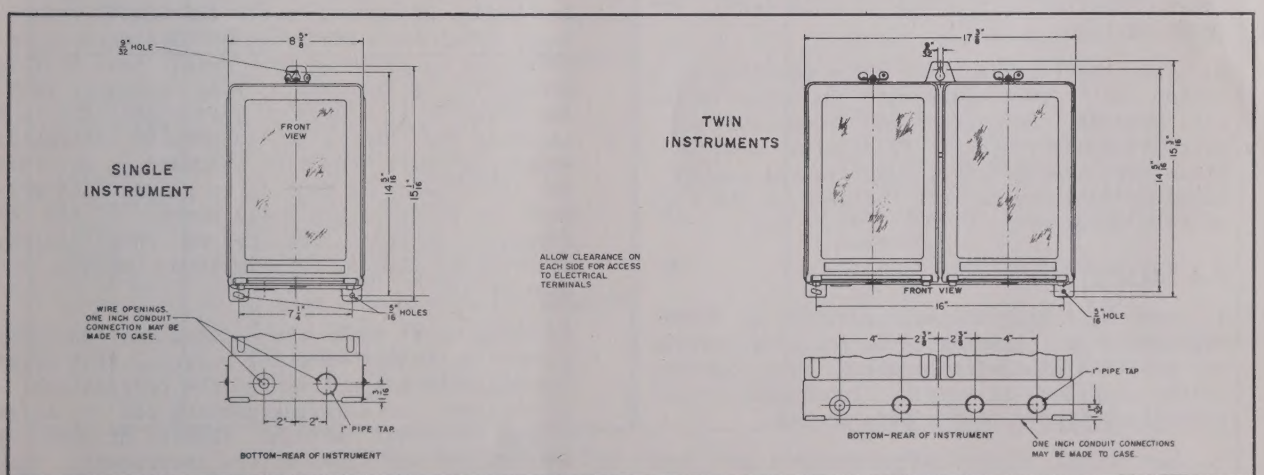

SINGLE INSTRUMENT
FRONT VIEW
WIRE OPENINGS. ONE INCH CONDUIT CONNECTION MAY BE MADE TO CASE.
BOTTOM-REAR OF INSTRUMENT
1" PIPE TAP
ALLOW CLEARANCE ON EACH SIDE FOR ACCESS TO ELECTRICAL TERMINALS
TWIN INSTRUMENTS
FRONT VIEW
BOTTOM-REAR OF INSTRUMENT
1" PIPE TAP
ONE INCH CONDUIT CONNECTIONS MAY BE MADE TO CASE.

Figure A5. Mounting Dimensions for Wall Style Cases.

sides of the case. See the mounting dimensional diagrams supplied in this section for either single or twin installations. For twin instruments, it is recommended that connections be made from the rear of the case before mounting.

TABLE A1
OVERALL INSTRUMENT DIMENSIONS

Case Style	Height	Width	Depth
Portable	14"a	8 9/16"h	9 5/16"bf
Flush	15 23/32" c	10 9/16"ci	8 3/4"bdg
Front	14" a	8 3/4" j	9 1/4"
Wall	15 1/16" e	8 5/8" j	10 15/16"
Twin Flush	15 23/32" c	19"ci	8 3/4"bdg
Twin Front	14"	17 1/2" j	9 1/4"
Twin Wall	15 3/16" e	17 3/8" j	10 5/8"

Table Legend:

a - From bottom of case to top of latch.
b - Add 3 1/2" (max) for standard, and 6 1/2" (max) for deep multiplier boxes.
c - applies to front flange and door.
d - Front panel to back of instrument. Maximum projection from front panel is 1 11/32".
e - Extreme bottom and top of mounting lugs.
f - Add 3/16" for Model A601R w/o multiplier.
g - Add 3/4" for Model A601R w/o multiplier.
h - Add 4" for external chart drive motor.
i - Add 2 7/8" for external chart drive motor.
j - Add 3 7/8" for external chart drive motor.

2.3 CONNECTIONS

a. Electrical connections for the measuring system and chart drive are made to either tapered plug holes, screw terminals, or binding posts at the rear of the instrument. Refer to PART C of this manual for specific connection instructions, and to the instrument Data Sheet supplied at the back of this manual for input ratings.

b. When the instrument is to be operated in a system with other equipment, Esterline Angus will provide information for recommended connections upon request. If special modifications have been ordered, supplemental instructions or drawings may be included in the back of this manual.

2.4 CASE LIGHTING

a. Internal lighting is provided in flush-type cases to illuminate the indicating scale and portions of the strip chart. The lighting system supplied is either fluorescent or incandescent (refer to the Data Sheet).

b. Electrical connections for the light module are made to a terminal block provided on top of the flush case. Twin instruments will have two separate light modules and two terminal blocks. The power ON-OFF switch is located on the left-front of each module, and is accessible with the case door open.

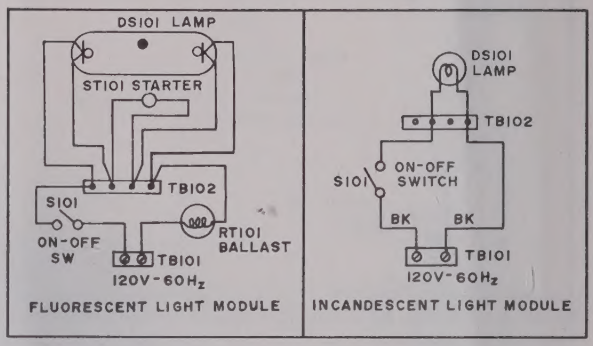


Figure A6. Case Lighting Diagrams.

2.5 STORAGE

If the instrument is to be placed in storage for an extended period, pack the unit in the upright position in its original shipping carton and store where it will be free from corrosive fumes, high humidity, and extreme temperatures.

CAUTION: If instrument is an ink recorder which will remain inactive for more than 30 days, all liquid ink should be removed and the inking system cleaned.

2.6 PACKING FOR SHIPMENT

a. If the instrument is to be returned to the factory, send for shipping instructions and state reason for return. In correspondence about the instrument, always identify it by model and serial numbers. The serial number is stamped on the instrument nameplate and will be found on the Data Sheet.

b. Before shipment, REMOVE ALL LIQUID INK (if used) from the instrument; considerable expense can be saved on many repair jobs if this precaution is followed. Wrap removable writing elements in paper or cotton and pack in a separate box. HANDLE ALL ASSEMBLIES CAREFULLY. Remove exterior mounting hardward. See that the front cover or door is in place, and protect the glass with a small board. If the instrument is to be repaired or recalibrated, return all leads, multipliers, shunts and accessories.

c. Wrap and seal the instrument in heavy paper to prevent packing material from sifting into the mechanism. Use the original shipping carton or a strong packing box - large enough to permit several inches of packing material on all sides of the instrument. Mark "HANDLE WITH CARE" and ship prepaid express to the Esterline Angus factory.

TABLE A2

CASE ASSEMBLY

REPLACEMENT PARTS LIST

PART NO.	DESCRIPTION
	PORTABLE, SWITCHBOARD AND WALL CASES
	Removable Front Cover Assy.
8761-13	Gray Wrinkle (Complete)
8761-10	Black Enamel (Complete)
8793	Glass, Front Window
8794	Glass, Top Window
01397	Gasket, Glass (Specify Length)
4892	Clip, Glass (6)
ST-43	Screw, Clip Mounting (6)
8808-A	Hinge Shaft
8799	Nameplate
8806	Latch Stud
X-2110	Stud Nut
8820	Bottom Slot Cover (Rubber)
0373	Rubber Gasket, Cover
	Cover (Less Parts)
8751-13	Gray Wrinkle
8751-10	Black Enamel
	Case Assembly (Complete)
8760A-13	Gray Wrinkle (Less Cover)
8760A-10	Black Enamel (Less Cover)
	Handle (Portable Only)
19790-G	Gray
19790	Black
NX-90806	Mounting Screw (4)
SP-1208	Washer (4)
X-2108	Mounting Nut (4)
8802	Latch Handle
8805	Mounting Screw
8804	Washer (Top)
NX-2111	Nut
X-107	Washer (Bottom)
8752	Hinge Hook (2)
17422	Heat Switch (Mod. A620T)
17450	Decal, Heat Switch
8935G	Power Cord (Portable Only)
	SINGLE AND TWIN FLUSH CASES
	Door Assy. (Single Case)
19872-12*	Charcoal (Complete)
19872-15*	Gray (Complete)
	Door Assy. (Twin Case)
19882-12*	Charcoal (Complete)
19882-15*	Gray (Complete
19830	Door Lock Assy.
19844	Front Glass (Single Case)
19848	Front Glass (Twin)
19826	Gasket, Glass (Specify Length)
19828	Clip, Glass (Right Side)
19836	Clip,Glass (Left Side)
19814	Clip, Top & Bottom Glass (Single)(2)
19838	Clip, Top & Bottom Glass (Twin)(2)
	Latch Assy.
19802-11	Charcoal
19802-14	Gray
19834	Clamp, Latch Pin (2)
19818	Hinge Pin, Latch Plate (Twin)(2)
19824	Gasket, Door (Specify Length)
	Nameplate (Single Case)
19840-D	Charcoal
19840-C	Gray
	Nameplate (Twin Case)
19840-B	Charcoal
19840-A	Gray
	Case Assembly (Single)**
19874-50	Charcoal (Less Door)
19874-14	Gray (Less Door)
	Case Assembly (Twin)**
19884-50	Charcoal (Less Door)
19884-14	Gray (Less Door)
19832	Lock Plate
19810	Retainer, Striker Plate
19809	Striker Plate Assy., Latch
19812	Flush Hinge (Single)(2)
19875	Flush Hinge (Twin)(2)
19816	Hinge Pin (2)
19877	Pin Bracket, Hinge (Twin)(2)
19888	Roll Pin (Twin)(2)
12895	Plug Button (As Req'd)
19715-1	Plastic Closure (As Req'd)
	Light Module (Complete)
19707-1	Fluorescent (2/Twin)
19707-2	Fluorescent (Mod. A620T)
19709-1	Incandescent (2/Twin)
19709-2	Incandescent (Mod. A620T)
19760	Terminal Block (TB101)
19733	Switch, ON-OFF (S101)
ND40073-2	Terminal Board (TB102)
19712	Fluorescent Lamp (DS101)
19723	Fluorescent Lamp Socket (2)
19740	Fluorescent Starter (ST101)
19727	Fluorescent Starter Socket
19725	Fluorescent Ballast (RT101)
081	Incandescent Lamp, 120V/15W (DS101)
082	Incandescent Lamp, 250V/10W (DS101)
19735	Incandescent Socket
17422	Heat Switch (Mod. A620T)(S102)
19717	Switch Decal (Mod. A620T)

* Add Suffix "-1" for chart feed-through door.

** Specify light module.

PART B

CHART DRIVE SYSTEM

SECTION 1 — DESCRIPTION

1.1 INTRODUCTION

a. This part of the manual includes a general description, operating procedures, and maintenance instructions on the various chart drives available for your Esterline Angus recorder. Refer to the Data Sheet which is supplied at the back of this manual for the specific chart drive supplied with the instrument.

b. The chart drive (Fig. B1) is an accurate and reliable paper-propelling mechanism which has been expressly designed for long trouble-free operation. Drive components are mounted on rigid box-like aluminum frames to maintain alignment of all parts, and thereby reducing gear-train friction and providing smooth chart feeds. On most electric drives, external connections are provided for remote operation.

c. Standard chart speed ranges are available from 3/16 inches-per-hour to 3 inches-per-second for "inch" drives, and from 12-1/2 millimeters-per-hour to 100 millimeters-per-second for "metric" drives. An almost limitless variety of chart speeds may be obtained through the use of change gears, auxiliary gearing, and special sychronous motors. The various standard chart speeds available are listed in Table B1 along with the chart drive number needed to obtain each speed range.

d. Series "A" chart drives are currently available in five basic design categories: Synchronous Motor, Hand-Wound Spring, Motor-Wound Spring, Selsyn Motor, and Phantom. With the exception of the phantom design, the internal power source for a drive is therefore either an electrical motor, stored energy in a mechanical spring, or a combination of these systems. Phantom drives require an external driving source, however they come equipped with either an internal electrical or mechanical system to reroll the chart paper.

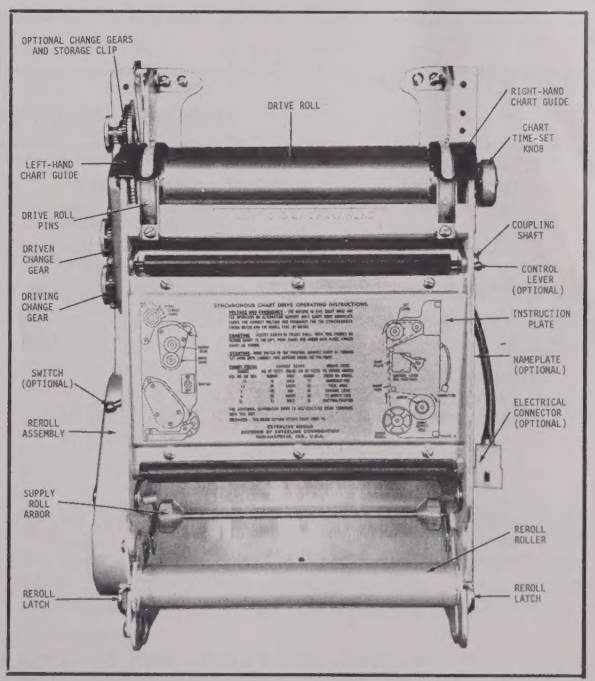


Figure B1. Typical Series "A" Chart Drive.

TABLE B1 STANDARD CHART SPEEDS

CHART DRIVE TYPE NO.	GENERAL DESCRIPTION	INCH DRIVES			METRIC DRIVES		
		inches per hour	inches per minute	inches per second	mm per hour	mm per minute	mm per second
1	Hand-wound Spring, Hour Speeds Only	¾, 1½, 3, 6, 12	.....	.....	12.5, 25, 50, 100, 200	.....	.....
2	Hand-wound Spring, Hour and Minute Speeds	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	.....	12.5, 25, 50, 100, 200	12.5, 25, 50, 100, 200	.....
2A	Hand-wound Spring, Hour and Minute Speeds with Electric Shift	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	....	12.5, 25, 50, 100, 200	12.5, 25, 50, 100, 200	.....
4	Synchronous Motor, Hour and Minute Speeds	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	.....	12.5, 25, 50, 100, 200	12.5, 25, 50, 100, 200	.....
4A	Synchronous Motor, Hour and Minute Speeds with Electric Shift	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	.....	12.5, 25, 50, 100, 200	12.5, 25, 50, 100, 200	.....
6X	Phantom, Spring Reroll, without Clutches	No power unit. One revolution of coupling shaft moves chart 3/4, 1 1/2, 3, 6 or 12 inches with corresponding gears in place. Coupling shaft supplied.			No power unit. One revolution of coupling shaft moves chart 12.5, 25, 50, 100 or 200 mm with corresponding coupling gears in place. Coupling shaft supplied.		
6C	Phantom, Spring Reroll, with Drag Clutch						
6CC	Phantom, Spring Reroll, with Drag and Back-up Clutches						
6EX	Phantom, Electric Reroll, without Clutches						
6EC	Phantom, Electric Reroll, with Drag Clutch						
6ECC	Phantom, Electric Reroll, with Drag and Back-up Clutches						
51	Motor-wound Spring, Hour Speeds Only	¾, 1½, 3, 6, 12	.....	.....	12.5, 25, 50, 100, 200	.....	.....
52	Motor-wound Spring, Hour and Minute Speeds	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	.....	12.5, 25, 50, 100, 200	12.5, 25, 50, 100, 200	.....
52A	Motor-wound Spring, Hour and Minute Speeds with Electric Shift	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	.....	12.5, 25, 50, 100, 200	12.5, 25, 50, 100, 200	.....
55	Synchronous Motor, Second Speed Only	.....	.....	¾, 1½, 3	.....	.....	12.5, 25, 50
56	Synchronous Motor, Hour and Minute Speeds, USED ONLY WITH 55 DRIVE	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	.....	12.5, 25, 50, 100, 200	12.5, 25, 50, 100, 200	.....
56A	Synchronous Motor, Hour and Minute Speeds with Electric Shift, USED ONLY WITH 55 DRIVE	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	.....	12.5, 25, 50, 100, 200	12.5, 25, 50, 100, 200	.....
60	Selsyn	¼, ½ or 1 inch per revolution of Sylsyn with ¾, 1½ or 3 inch gears in place.			6.25, 12.5, 25 mm per revolution of Selsyn with 24 and 64 tooth, 39 and 52 tooth and 54 and 36 tooth gears in place.		
60C	Selsyn with Back-up Clutch						

Note: Additional speeds are available. See instrument Data Sheet for specific drive and speeds supplied.

1.2 SPECIFICATIONS

TABLE B2. CHART DRIVE CHARACTERISTICS

Driving Sources:
- Spring Types . . . . . Manual or Motor Wound*
- Synchronous Types . . . . Internal (AC-Line Synchronous) Motor*
- Selsyn Types . . . Remote Controlled Internal Selsyn**
- Phantom Types . . Spring or Electric Reroll (Requires External Drive)***

Standard Speeds:
- Inches/Unit Time . . 0.75, 1.5, 3.0, 6.0, 12
- Centimeters/Unit Time 1.25, 2.5, 5.0, 10, 20 (See Table B1)

Power Requirements:
- Electrical Drives/Reroll . . . . See Table B3
- Manual Spring Drives . . . . . None
- Phantom (Spring Reroll) . . . . . None

Dielectric Test . . 1,500V, 60Hz for one minute

Recording Media:
- Inking Charts . . . . 6" X 103' (15mm X 30m)
- Thermal Charts . . . . 6" X 81' (15mm X 24m)
- Channel Width
  - Model A601R, A601C . . . 4-1/4" active span
  - Model A602C . . . . . two 2" active spans
  - Model A609C .one 2-3/4" active analogue span and eight event channels
  - Model A620X, A620T . .twenty event channels

Controls (Optional)
- Power (On-Off) . . . . . Two-Position Switch
- Hour/Minute Selector . . . Two-Position Lever
- Rate Selection . . . . . Manual Change Gears
- Chart Advance (Time Set) . . . . Manual Knob

Remote Control:
- Chart Drive . . External Connections Provided

Attachment:
- External Motor . . . . . See Table B4

* Available with Electric Shift for remote selection of Hour-Minute speeds.
** Available with Back-Up Clutch protection.
*** Available with Drag and/or Back-Up clutches.

NOTE: All drives except Selsyn types may be supplied with a set of manual change gears.

TABLE B3
ELECTRICAL RATINGS

CHART DRIVE TYPE NO.	Internal Motors			Internal Electric Shift Coils				
	AC Volts	Frequency Hz	Load of Drive Motor and Reroll Motor AC (VA)	DC Volts	AC Volts	Frequency Hz	DC Load Watts	AC Load VA
2A	.....	.....	.....	6, 12, 24, 48	6-120	50, 60	1.4[c]	2.4[c]
4	120, 240[a]	50, 60	26					
4A	120, 240[a]	50, 60	26	6, 12, 24, 48	120, 240	50, 60	10[d]	16[d]
6EX	120, 240[a]	50, 60	15					
6EC	120, 240[a]	50, 60	15			.....		
6ECC	120, 240[a]	50, 60	15					
51	120, 240[b]	50, 60	30					
52	120, 240[b]	50, 60	30					
52A	120, 240[b]	50, 60	30	6, 12, 24, 48	6-120	50, 60	1.4[c]	2.4[c]
55	120	60	25					
56	120	60	26					
56A	120	60	26	6, 12, 24, 48	6-120	50, 60	10[d]	16[d]
60	120	50, 60	75					
60C	120	50, 60	75					

[a]Electric chart drives are normally furnished for one voltage only. 120/240 volt, 50 or 60 Hz drives are available. Number 4 drives can also be rated 120/240/480 volt, 60 Hz.

[b]Single voltage ratings only are supplied.

[c]Both AC and DC speed shift coils are designed for continuous operation.

[d]AC speed shift coils are designed for continuous operation. DC speed shift coils should be energized intermittently, not more than five minutes on, followed by equal off period.

TABLE B4
EXTERNAL MOTOR ATTACHMENTS

TYPE	DESCRIPTION	Chart Speeds Inches per Second	Chart Speeds mm per Second	Motor Ratings				
				DC Volts	AC		DC Load Watts	AC Load VA
					Volts	Frequency Hz		
N	Second Speed Non-reset	¾, 1½, 3	12.5, 25, 50, 100	12, 24, 48, 125, 250	120	50, 60	22	60
R	Second Speed, with Time Reset	¾, 1½, 3	12.5, 25, 50, 100	24, 48, 125, 250	120	50, 60	22	60

SECTION 2 — OPERATION

2.1 GENERAL

a. Chart drive operating procedures will vary slightly depending upon the particular type of drive supplied with the recorder. To prepare a typical drive for use, electrical or mechanical connections may be necessary, proper change gears may have to be selected, and the chart paper correctly installed. Basic operating procedures are given on the instruction plate which is attached to the front of each drive.

b. Do not attempt to put the instrument into operation until all instructions have been thoroughly studied. Make sure all items are unpacked and all shipping materials are removed from the instrument. This includes any cardboard or tie-strings that may be securing writing elements, optional change gears, scale-plates, or chart rollers. Failure to make proper connections or to make necessary checks and adjustments may result in unsatisfactory operation or damage to the instrument.

2.2 CONNECTIONS

2.2.1 Electrical

a. All connections for electric drives are made at the rear of the recorder case. Refer to Part C of this manual for specific connection instructions, and to the Data Sheet supplied at the back of this manual for input ratings.

b. Drives equipped with an electric shift to change chart feed rates automatically from hour to minute have a separate pair of terminals on the back of the recorder. Voltage and

frequency of the electric shift feature are not always the same as that of other internal motors.

2.2.2 Mechanical

a. All chart drives, except the selsyn, are equipped with a through driving shaft for external coupling. Selsyn drives also have an external coupling, but it is provided only on the left side of the mechanism. These couplings may be used to either propel the chart from an external source, couple two separate drives for synchronization, or to connect a self-powered drive to a phantom drive--such as in a twin-case recorder.

b. When driving the chart from an external source, a clutch will be provided between the internal drive system and the external coupling shaft. The external power source must be sufficiently large to overcome friction in this clutch---approximately one to two inch-pounds. If rotation of the external source can be reversed, the chart drive must also be equipped with a back-up clutch to prevent the chart from running backward. The back-up clutch is located on the right-hand side of the drive, and therefore the external source must be attached to this side only.

c. Mechanical connections for external sources or for the coupling of two chart drives are made to the ball and cross pin provided on the end of the external coupling shaft. Flexible couplings and extension shafts of various lengths are available from Esterline Angus and may be supplied with the recorder.

NOTE: It is not desirable to couple two synchronous drives. If set to the same time of day and operated from the same source, however, they will stay synchronized.

d. Motor-wound spring drives should not be coupled to each other but may be coupled to the phantom drive in a twin recorder, or to an external driving source. Two hand-wound spring drives may be coupled to synchronize chart timing. The drives must be in good condition and timed accurately, or they may stop. Coupled drives will operate at both hour and minute feeds.

e. The phantom coupling is suitable for coupling the power chart drive in a twin instrument to the phantom chart drive. It is made to spring over the coupling ball fittings and eliminates any lost motion or backlash between the two drives. It is not suitable for transmitting heavy torque and does not take the place of the power couplings, such as those used for external motor drive devices. Excessive torque on a phantom coupling will damage it.

2.3 CHARTING PROCEDURES

a. To maintain guaranteed accuracy and insure optimum performance, always use Esterline Angus precision charts in this instrument.

b. Open the case and see that the chart drive is off. For instruments with front covers hinging at the bottom of the case, remove the cover completely to facilitate preparation for operation. Raise the hinged scaleplate and, if provisions are made, either raise or remove the writing elements. It is also recommended that the measuring system be de-energized. Proceed with the following steps.

WARNING: On instruments having thermal writing elements, avoid direct contact with heated styluses.

(1) Press down on either the right or left reroll latch near the bottom of case and remove reroll roller as shown in Figure B2.

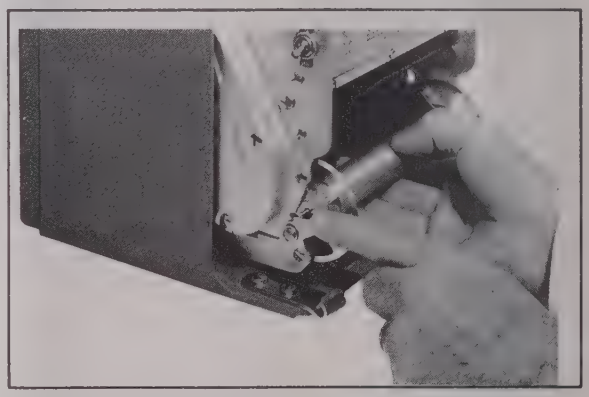


Figure B2.

(2) Remove the chart roll arbor by lifting it up and pulling forward as shown in Figure B3. Center the paper roll on arbor with elongated perforations to right.

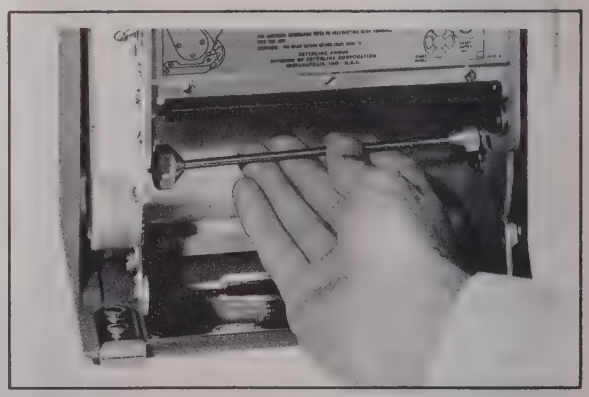


Figure B3.

(3) Snap the ends of the arbor with the new chart into the slots as shown in Figure B4. See that chart supply roll turns freely.

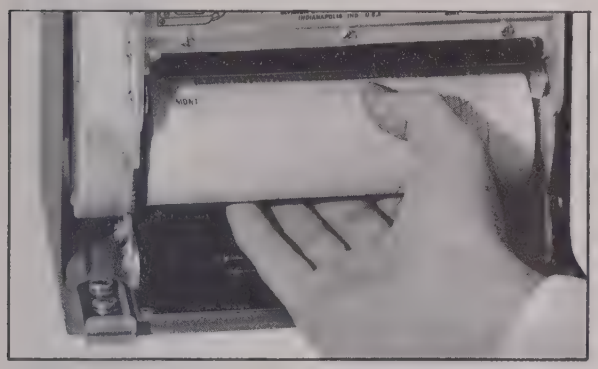


Figure B4.

(4) Tear or cut end of chart into "V" shape. Feed chart into slot marked "INSERT END OF CHART HERE" as shown in Figure B5. Push in until point appears above and behind top drive roller. (Feed under small hold-down roller on Model A601RT only.)

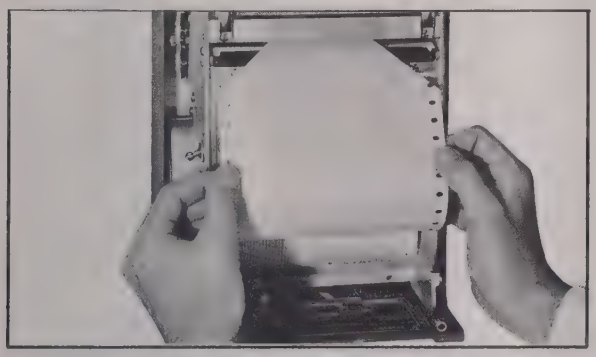


Figure B5.

(5) Feed chart over front of drive roller. Carefully pull the chart down while turning knurled knob at the end of roller, as shown in Figure B6, so roller pins engage chart perforations.

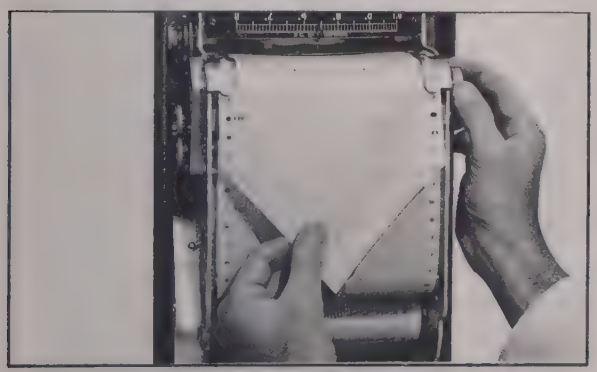


Figure B6.

(6) Snap reroll roller in place (gear end to left) and insert "V" end of chart into roller slot as shown in Figure B7. Turn the reroll roller back 1/4 turn (window blind action). Advance the set knob while permitting chart to reroll.

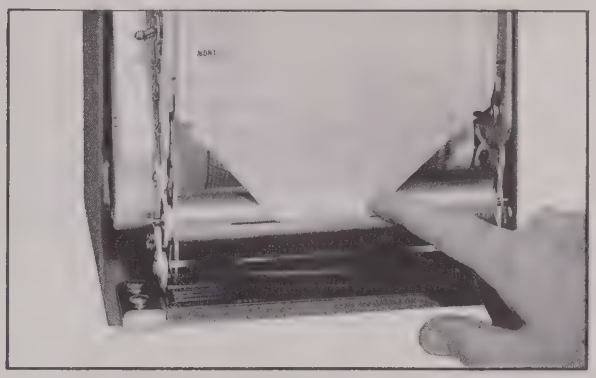


Figure B7.

c. It may be necessary to momentarily energize an electric drive before the reroll will take up the chart. Make sure that the chart is straight and taut. The chart is now installed and ready for operation.

d. A portion of the chart may be unwound from the reroll for inspection by pulling straight out on the chart paper. To stop the reroll action and examine the chart at leisure, release the chart suddenly after a desired length has been pulled from the reroll. This will lock the reroll roller in position. Rewind the chart by pulling it forward slightly and then letting it wind slowly back onto the reroll.

NOTE: To insure accurate recording, always see that the chart paper is straight on the reroll.

e. Instead of rerolling the chart in a conventional manner, provisions may be made for feeding used chart out of the bottom of any instrument case. This is accomplished by removing the rubber strip (or section of gasket) at the lower edge of the case cover or door. The end of the chart hanging out of the case should be weighted; a two-ounce clamp-on device is sufficiently heavy for this purpose. Do not pull or jerk on the end of the chart as this may throw it out of time or disengage the chart from the roller pins.

2.4 CHART REMOVAL

To remove an entire rerolled chart, push down on one of the reroll latches and pull the chart roll forward and out of the instrument. The chart paper may then be removed from the reroll roller by holding the disk at the gear end of

the roller, pulling out the plug from the opposite end, and sliding the chart from the tube. If the chart is wound too tightly, twist the roller counterclockwise as it is being withdrawn from the chart.

2.5 CHANGE GEARS

a. The instruction plate on the front of all standard power drives shows the path traveled by the chart, change gears to use for each standard speed, and how to start and stop the drive. Optional change gears are stored on a clip at the upper left corner of the drive; change gears for special speeds, if any, are stored at the upper right corner.

b. To change gears, proceed as follows:

(1) Hold the lower drive gear with one hand and unscrew two knurled nuts securing drive gear and driven gear to their respective shafts.

(2) Remove gears by pulling straight outward.

CAUTION: Do not pry gears off of shafts.

(3) Install selected gears with keyway in hub engaging key on shaft. Secure gears by hand tightening the knurled nuts.

TABLE B5

STANDARD SPEEDS AND CHANGE GEARS

Chart Speed Inches Per Hour or Minute	Change Gears		Color of Driver & Driven Change Gears
	No. of Teeth (Driver)	No. of Teeth (Driven)	
3/4	18	72	Gold
1-1/2	30	60	Green
3	45	45	Red
6	60	30	Green
12	72	18	Gold
CHART TRAVEL VS. SELSYN ROTATION			
Inches of Chart Travel Per Revolution of Selsyn	Change Gears		Color of Driver & Driven Change Gears
	No. of Teeth (Driver)	No. of Teeth (Driven)	
1/4	18	72	Gold
1/2	30	60	Green
1	45	45	Red
NOTE: See Data Sheet included in the back of this manual for special chart speeds			

2.6 OPERATING PROCEDURES

To put the drive into operation, follow the subsequent instructions that apply to the type of drive used in your instrument. Basic operating instructions are also located in the front plate of each chart drive.

2.6.1 Hand-Wound Spring Drive

a. Raise the control lever on the left side of the chart drive from the stop position to the hour feed mark for hour feeds, or to the minute feed mark for minute feeds. Speed selection can be accomplished by actuating an electromagnet on models equipped with electric shift. AC and DC shift coils for this drive are designed for continuous operation. See the Data Sheet for electrical ratings.

b. A white target, visible through the small window at the left edge of the instruction plate, moves up and down when the drive is running. If the drive does not start immediately, move the control lever up and down a few times. When the chart is started in minute feed, there is a slight lag in getting up to correct speed. This is due to a flyball governor which requires time to reach full speed.

c. Power to operate a hand-wound spring drive is stored in four identical springs connected in series. Phantom chart drives with spring reroll use only two springs. The springs are wound simultaneously.

d. To wind, insert the square end of the winding crank into the winding arbor, push the arbor in as far as it will go and, at the same time, turn steadily in a clockwise direction. When the springs are fully wound, the winding crank will refuse to turn. Be sure the chart drive is fully wound before stopping. A partial turn in the reverse direction, while withdrawing the winding crank, completes the winding operation. The winding arbor is then forced out to its original position by a spring which also disengages the worm from the worm gear inside the housing.

e. If the springs have been unwound completely, it requires about 110 turns of the winding crank to rewind a spring chart drive, or about 55 turns for a phantom drive with spring reroll.

f. The chart is designed to operate for eight days at any of the standard hour feeds. Approximately 65 turns of the crank are required to replace the energy used in eight days' operation. Winding once per week or each time the chart is replaced (whichever occurs first) is recommended. When running the chart at minute feeds, wind the springs every four hours for continuous operation.

2.6.2 Synchronous Motor Drives

a. This type of drive employs two internal motors--a line synchronous motor for timing the chart speed, and a separate induction

motor that powers the reroll mechanism. Electrical input ratings for these motors will be specified on the instrument Data Sheet.

b. HOUR-MINUTE OPERATION: Move the "Start-Stop" switch, located on the left side of the drive, to "ON". Place the hour-minute feed lever, located on the right side of the drive, to the desired position by moving the lever manually or by actuating the electro-magnet on instruments equipped with electric shift. All AC shift coils for hour-minute drives are designed for continuous operation; however, DC shift coils should be energized intermittently--not more than five minutes on, followed by an equal off period.

CAUTION: Do not energize drive motor and electric shift simultaneously as this may cause the drive to stall.

c. SECOND SPEED OPERATION: On second-speed synchronous drives, the "Start-Stop" switch, located on the left side of the unit, controls only the internal reroll motor. The internal synchronous motor must be controlled by an external switch or relay.

NOTE: Fast chart speeds are not recommended for recorders having thermal writing elements.

d. Since a second-speed drive is normally used in the right side of a twin instrument and is coupled to an hour-minute synchronous drive in the left side, the reroll induction motor must operate independently from the internal synchronous motor. An uninterrupted power supply must be furnished for the reroll motor. Separate power-input terminals are provided for each motor.

NOTE: The drive motor may coast for a period up to 1.5 seconds after power is shut off; consequently, any chart record obtained during this period will not be accurately timed.

2.6.3 Motor-Wound Spring Drives

a. Move the switch on the right side of the drive to its "ON" position, then raise the control lever on the left side from its stop position to the hour feed mark for hour feeds, or to the minute feed mark for minute feeds. Speed selection can be accomplished by actuating an electromagnet on instruments equipped with electric shift. AC and DC shift coils for this drive are designed for continuous operation. Electrical ratings for the drive motor and shift coil will be specified on the instrument Data Sheet.

b. If storage springs are unwound, the push-button on the right side of the drive must be held down for approximately one-and-a-half minutes to rewind the springs. A white target, visible through the small window at the left edge of the instruction plate, moves up and down when the drive is running. If the drive does not start immediately, move the control lever up and down a few times. When the chart is started in minute feed, there is a slight lag in getting up to correct speed. This is due to a flyball governor which requires time to reach full speed.

2.6.4 Selsyn Drive

a. Power to a selsyn chart-drive system is supplied by the user. These drives are operated by an internal selsyn receiver. Chart feed rates provided by this drive are given in Table B5 under "Change Gears."

CAUTION: Selsyn speed should not exceed an RPM which corresponds to a chart speed of 12 inches per minute for satisfactory inkless recording.

b. The motor for an electric reroll in a selsyn drive is rated at 120 volts, 60Hz. See the instrument Data Sheet for recommended electrical ratings. When required, a connection diagram for transmitting and receiving selsyns will be supplied in the Appendix of this manual. Refer to the special supplement on selsyn devices for additional operating instructions.

2.6.5 Phantom Chart Drive

The chart in this type of drive is propelled by an outside source, however, they do have their own system for reroll. To activate the reroll on electric reroll models, move the power switch on the left side of the drive to "ON". It is necessary only to wind the spring on models with spring reroll. See "Hand-Wound Spring Drive" in this section for spring winding instructions. If an electric reroll is supplied, refer to the instrument Data Sheet for power ratings.

2.7 EXTERNAL MOTOR ATTACHMENTS

a. An external motor attachment consists of a fractional horsepower motor and gear box which mounts on the right side of the recorder case and couples to the internal drive system. Fast chart speeds are obtainable with this attachment.

CAUTION: High chart speeds are not recommended for recorders having thermal (inkless) writing elements.

b. Optional change gears supplied with the internal drive determine the chart speed. The

external motor moves the chart 3600 times the normal hour speed. Usually, 3/4 inch per second is recommended, as this speed is high enough to record any variations that the recorder can follow. Electrical power must be maintained to the internal synchronous, motor-wound spring, and electric phantom chart drives to assure continuous reroll action.

c. Instruments supplied with a high-speed motor attachment will require more careful attention than those operating at slow chart speeds. For example, it is recommended that the recorder inking system be flushed and cleaned much more often than normally required, and that the pen pressure (weight) always be sufficient to hold the pen on the chart during high-speed operation. The chart paper must also be kept clean and dry; it must be properly threaded and rerolled straight on the reroll roller. It is a good practice to keep the case cover or door closed whenever possible.

2.7.1 Style 24 (Type N)

This external motor drive is a non-reset type. To start the chart operating at high speed, it is only necessary to energize the external motor. This can be done with the switch on the top of the gear box, or this switch can be left in the "on" position and the motor started by closing another switch or a pair of relay contacts at some remote point. The chart continues to move at high speed as long as the motor is energized and stops when it is de-energized.

2.7.2 Style 22 (Type R)

a. This external motor drive operates in the same manner as Type N, except that it resets the chart to the correct time of day after each high-speed operation. It must be energized from an unfailing power supply.

b. On this drive, the chart is started operating at high speed when the external motor is energized by a pair of relay contacts. When the trip circuit is de-energized, a lock-in circuit causes the motor to continue running until the chart is again set for the correct time of day. To insure lock-in, the trip circuit must remain closed for approximately 1/5 second. For test purposes, a spring-loaded test switch located on the top of the gear box will also start the drive.

SECTION 3 — MAINTENANCE

3.1 GENERAL

The chart drive is a very important part of a graphic recording instrument. The drive system must move the chart consistently at the correct speed under all conditions. The drive selected for use in the recorder converts either electrical or mechanical energy into linear physical motion of the chart paper. Refer to the Data Sheet in this manual for the chart drive supplied, and to Table B6 for a description of the specific type and factory style number.

3.2 ROUTINE MAINTENANCE

a. The components employed in each chart drive assembly are of sturdy construction and are designed for long trouble-free operation. Nevertheless, they should receive the care afforded any precision piece of equipment to extend their useful life. Should adjustment or minor service become necessary in the field, refer to the following maintenance procedures. In the few cases where major repairs are necessary, contact your local Esterline Angus representative for instructions.

WARNING: To prevent accidental shock, always remove power from the instrument before disassembling or servicing.

b. Periodic maintenance schedules should be established which include inspecting, cleaning, adjusting, and lubricating. A recorder operating continuously (24 hours daily) should be inspected and lubricated once a year. A recorder used periodically should undergo a visual inspection and lubrication once every three years.

3.2.1 Inspection

a. Visual inspection of the chart drive should be made at each maintenance period with particular attention to the following:

(1) Accumulation of dirt or other foreign material on outer surfaces or within the drive mechanisms.

(2) Misadjusted chart guides or damaged control levers.

(3) Loose screws, couplings, nuts, or other hardware.

TABLE B6

SERIES "A" CHART DRIVES

CATALOG TYPE NUMBER	CHART DRIVE DESCRIPTION	FACTORY STYLE NO. APPLICABLE RECORDER MODELS			
		A601C, A602C A609C, A620X	A601R*	A601RT	A620T
1	Hand-wound Spring, Hour Speeds Only	80-H	83-H	85-H	80-HT
2	Hand-wound Spring, Hour and Minute Speeds	80-M	83-M	85-M	80-MT
2A	Hand-wound Spring, Hour and Minute Speeds with Electric Shift	180-MS	83-MS	85-MS	180-MST
4	Synchronous Motor, Hour and Minute Speeds**	190-M	93-M	95-M	190-MT
4A	Synchronous Motor, Hour and Minute Speeds with Electric Shift	190-MS	93-MS	95-MS	190-MST
6X	Phantom, Spring Reroll, without Clutches	81-P	83-P	86-P	81-PT
6C	Phantom, Spring Reroll, with Drag Clutch	82-P	84-P	87-P	82-PT
6CC	Phantom, Spring Reroll, with Drag and Back-up Clutches	82-PC	84-PC	87-PC	82-PCT
6EX	Phantom, Electric Reroll, without Clutches	191-P	93-P	95-P	191-PT
6EC	Phantom, Electric Reroll, with Drag Clutch	192-P	94-P	96-P	192-PT
6ECC	Phantom, Electric Reroll, with Drag and Back-up Clutches	192-PC	94-PC	96-PC	192-PCT
51	Motor-wound Spring, Hour Speeds Only	201-H	104-H	105-H	***
52	Motor-wound Spring, Hour and Minute Speeds	201-M	104-M	105-M	***
52A	Motor-wound Spring, Hour and Minute Speeds with Electric Shift	201-MS	104-MS	105-MS	***
55	Synchronous Motor, Second Speed Only	190-B	93-B	***	190-BT
56	Synchronous Motor, Hour and Minute Speeds, USED ONLY WITH 55 DRIVE	190-S	93-S	***	190-ST
56A	Synchronous Motor, Hour and Minute Speeds with Electric Shift, USED ONLY WITH 55 DRIVE	190-SS	93-SS	***	190-SST
60	Selsyn	202	103	106	202-T
60C	Selsyn with Back-up Clutch	202-C	103-C	106-C	202-CT

* An additional "-2" suffix to the Style No. indicates a cartridge-type inking system.

** A "-MMR" Style No. suffix indicates multi-range for operation on both 120 and 240 volts AC.

*** Style available but not recommended for this application.

(4) Evidence of excessive wear in moving parts of the drive.

(5) Damaged wiring, loose connections, or defective switch.

b. If any of the above are evident, corrective measures should be taken without delay.

3.2.2 Cleaning

a. Dirt, dust,or other foreign bodies are not conducive to long life of working parts, and precautions should be taken to prevent admission of these substances into the chart drive assemblies. Regardless of the precautions taken, dirt will enter the case and therefore the chart drive should be cleaned periodically--depending upon environmental conditions.

b. Remove chart paper, reroll roller, supply arbor, change gears, and front instruction plate before cleaning. All surfaces should be carefully cleaned using a soft-bristled brush or low vacuum system. Mild soap or detergent may be used to clean rollers and to wipe off all outer surfaces of the drive.

CAUTION: Do not disturb mechanical alignment of parts or routing of wiring during cleaning procedures.

c. Ink or other liquids, if spilled on the chart drive mechanism, should be removed promptly. EA recording ink is water-based and may be removed with a wet cloth. Other liquids must be removed by means appropriate to their nature.

d. Dirt may be removed, especially when lodged in lubricating grease,by use of a suitable brush and a mild solvent--such as benzine. Harsh solvents such as acetone or paint brush reconditioners should not be employed. When a solvent has been used, parts should be allowed to dry thoroughly before a lubricant is applied.

CAUTION: Do not use excessive amounts of cleaning solvents on oil-impregnated bearings.

3.2.3 Lubrication

a. The chart drive should undergo a thorough cleaning before lubricating. The lubricants specified in this manual are for use on drives operating at average temperatures from 20° to 100°F. If a drive is to be operated in temperatures outside of this range,special lubricants may be required (consult the factory).

CAUTION: Allow sufficient time for cleaning solvents to dry before lubricating parts. DO NOT over lubricate.

b. BEARING PLATES: All chart drive bearings should be oiled as illustrated in Fig. B8. Use EA 40 Oil on all impregnable bearings, and heavy-weight Nonpareil Oil on all other bearings--except in escapements. Do not oil ratchets and pawls; they operate better when dry.

c. GEARS AND SPRINGS: All gear teeth should be lubricated with EA Mainspring Grease as shown in Fig. B8. The mainsprings employed in a spring chart drive should also be lubricated with this grease. Mainsprings will seldom require regreasing; however, when spring lubrication is necessary, the drive must be partially disassembled. It is recommended that this work be done in a meter repair shop or the entire unit be returned to Esterline Angus for factory service.

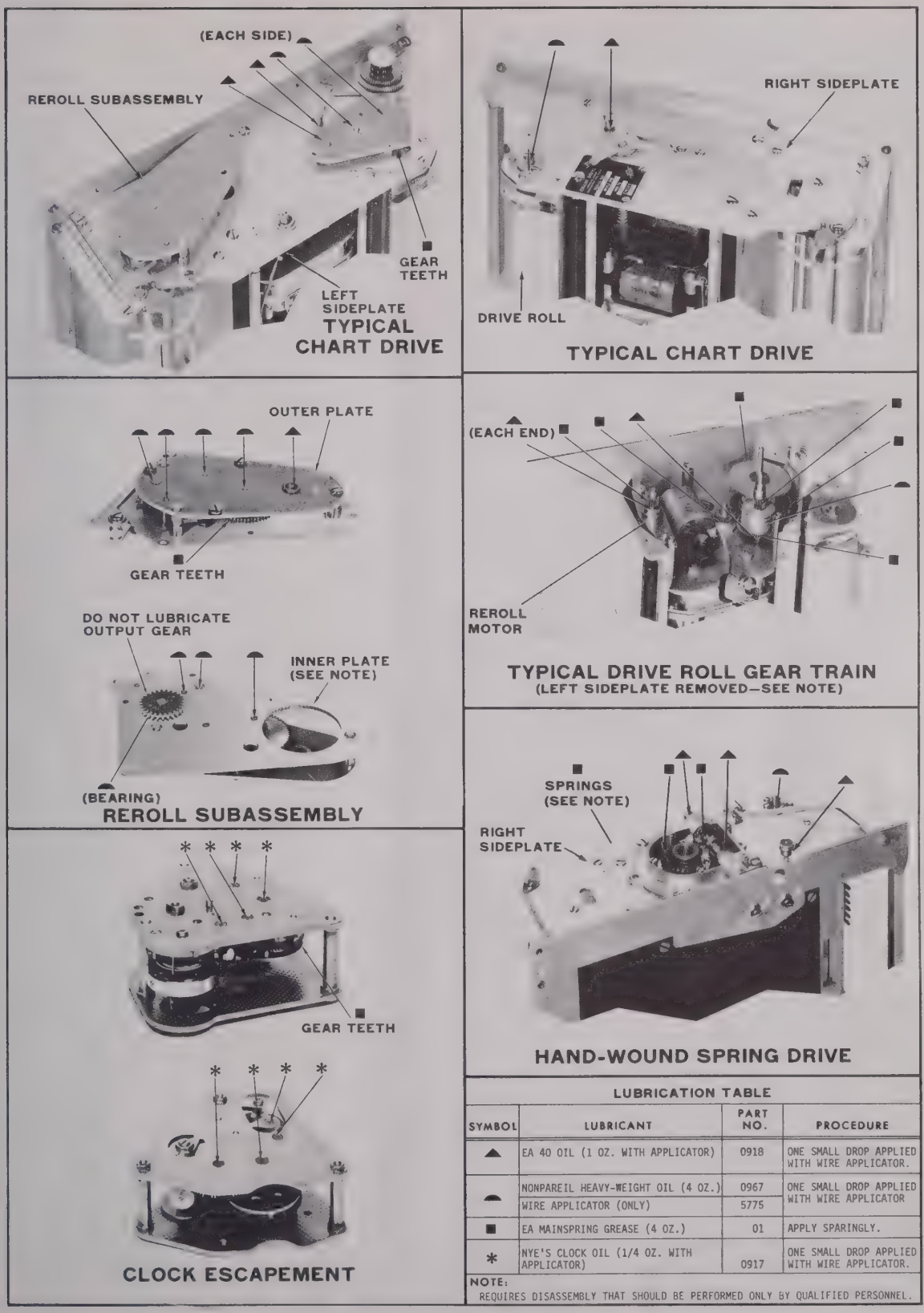
d. ELECTRIC MOTORS: Bearings of reroll or spring-winding motors should be lubricated with EA 40 Oil once a year. Hour-minute synchronous motors, selsyn units, and EA external motors are lubricated for life; do not attempt to relubricate.

e. The gear trains associated with an external motor attachment may be oiled from a single lubrication point located on top of the external gear box. Use EA 40 Oil for this application. Internal second-speed motors should be oiled with medium-weight Nonpareil Oil (#0966) every six months. Add ten drops of oil to each red hole in the motor. Remove the chart feeder plate from the top of the drive; the oiling holes are then accessible by means of a long-spouted oil can.

f. ESCAPEMENTS: Clock escapements employed in spring chart drives must be lubricated with Nye's Superior Clock Oil only. Always see that the mechanism is clean before applying the lubricant. Oil all bearing points as illustrated in Fig. B8. A small quantity of EA Mainspring Grease should also be applied to the teeth of each escapement gear. Do not oil ratchets and pawls; they operate better when dry.

3.3 CHART GUIDE ADJUSTMENTS

a. The chart guides are properly adjusted at the factory and their positions normally should not be changed. However, if the drive has been subjected to rough handling or disassembled, readjustments will be necessary.



LUBRICATION TABLE

SYMBOL	LUBRICANT	PART NO.	PROCEDURE
▲	EA 40 OIL (1 OZ. WITH APPLICATOR)	0918	ONE SMALL DROP APPLIED WITH WIRE APPLICATOR.
▬	NONPAREIL HEAVY-WEIGHT OIL (4 OZ.)	0967	ONE SMALL DROP APPLIED WITH WIRE APPLICATOR
	WIRE APPLICATOR (ONLY)	5775	
■	EA MAINSPRING GREASE (4 OZ.)	01	APPLY SPARINGLY.
*	NYE'S CLOCK OIL (1/4 OZ. WITH APPLICATOR)	0917	ONE SMALL DROP APPLIED WITH WIRE APPLICATOR.

NOTE:
REQUIRES DISASSEMBLY THAT SHOULD BE PERFORMED ONLY BY QUALIFIED PERSONNEL.

Figure B8. Chart Drive Lubrication Points.

b. The correct position of the chart guides is evident when there is no tendency of the paper to be depressed into the grooves on the drive roll. The turned down edge "A", Fig. B9, should follow the contour of the drive roll but allow clearance for the chart paper, so that there is no drag on the paper. It may be necessary to loosen two screws "B", Fig. B10, in order to facilitate this adjustment. Screw "C" may also be loosened, when necessary, to provide parallel positioning of chart guides with relation to the side plates.

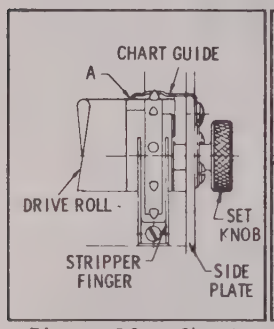


Figure B9. Chart Guide (Front View).

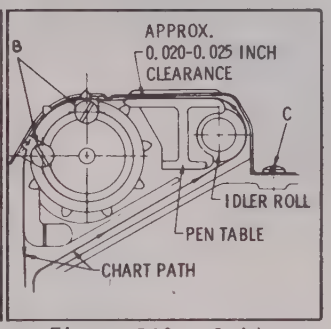


Figure B10. Guide Adjustment (Side View).

3.4 RECORDING TIMETABLE

Esterline Angus charts are currently available in useful lengths of 103 feet (Ink Types); and 81 feet (Thermal Types). The total running time for any chart will, of course, depend upon the chart speed employed. Chart running times for various chart speeds are shown in the following table.

STANDARD (INCH) CHART SPEEDS	CONTINUOUS RUNNING TIME* (MIN.)	
	INK CHARTS	THERMAL CHARTS
3/4 In/Hr.	65-2/3 Days	51 Days
1-1/2 In/Hr.	32-1/3 Days	25-1/2 Days
3 In/Hr.	15-2/3 Days	12-3/4 Days
6 In/Hr.	7-1/3 Days	6-3/8 Days
12 In/Hr.	3-2/3 Days	3-3/16 Days
3/4 In/Min.	26-2/3 Hrs.	20-4/5 Hrs.
1-1/2 In/Min.	13-1/3 Hrs.	10-2/5 Hrs.
3 In/Min.	6-2/3 Hrs.	5-1/5 Hrs.
6 In/Min.	3-1/3 Hrs.	2-3/5 Hrs.
12 In/Min.	1-2/3 Hrs.	1-3/10 Hrs.
3/4 In/Sec.	26-2/3 Mins.	20-3/4 Mins.
1-1/2 In/Sec.	13-1/3 Mins.	10-3/8 Mins.
3 In/Sec.	6-2/3 Mins.	5-3/16 Mins.

* All calculations take into consideration 3 feet of chart for installation. Charts for Hour Speeds also allow for the loss of an entire 24 hour period, so that they may always be set to the time of day.

3.5 CHART DRIVE SERVICING

3.5.1 Synchronous

a. Each synchronous chart drive contains two electric motors - the synchronous timing motor and an induction motor driving the reroll. Removal of these motors will require major disassembly and should be done only at the factory or in a well-equipped instrument shop.

b. The reroll gear train may be replaced as a complete unit; or, the reroll storage spring assembly only may be replaced. In either case, be sure to "let down" the reroll spring before attempting disassembly. With power off, hold the chart reroll roller in the hand and let it revolve slowly until it turns no longer. Damage may result if disassembly is attempted with energy stored in the spring.

3.5.2 Hand-Wound Spring

a. Before attempting any repair work on this chart drive, the springs must be completely unwound. If this is not done, spring power may be released suddenly and cause damage to the chart drive or injury to the operator.

b. UNWINDING THE SPRINGS: To let down or unwind the springs, take the chart drive out of the case per "Disassembly" instructions. Do not replace the chart reroll. Remove the reroll gear cover by removing the four screws holding it in place. Lay the drive on its back. Insert the winding crank with one hand and push the reroll release pin to the left with the other. This pin projects out of the left-hand sideplate. Its location is shown on the instruction plate. The release pin will slide easily if the crank is held so that the pressure on the pin is relieved. Do not force the pin. Holding firmly to the winding crank, allow it to turn slowly in a counterclockwise direction until the springs are completely unwound. Springs are unwound when the crank no longer tries to turn. Do not let go of crank until the springs are unwound. When servicing is completed, push the reroll release pin to the right (to its original position), replace the reroll gear cover, and wind the springs as required.

c. REPLACING THE SPRINGS: Let down the springs; see "Unwinding the Springs" instructions. Take off the winding bracket by removing the four screws which hold it to the right sideplate. With the instruction plate off, the spring assembly can be withdrawn through the hole in the right sideplate. New spring assemblies may be installed and the winding bracket replaced. The springs are now ready for winding.

d. THE ESCAPEMENT: A hand-wound spring chart drive is timed by one of three escapements. The hour-feed escapement will provide only hour feeds. The minute-feed escapement contains both the hour-feed timing mechanism and a flyball governor to time minute feeds. An hour-feed chart drive can be changed to minute feed by changing escapements. The third type of escapement is used in drives equipped with an electric shift for automatic change from hour to minute feeds.

NOTE: Repair of escapements, except at the Esterline Angus factory, is not recommended. For repair, install a spare escapement in the instrument and return the worn one to the factory for servicing. When ordering new escapements, include the part number located on the left sideplate of the old escapement.

e. ESCAPEMENT REMOVAL: The escapement assembly can be removed without major chart drive disassembly. First, follow instructions under "Unwinding the Springs." Next, remove the control lever and three screws holding the escapement to the left-hand sideplate of the drive. The escapement is accurately positioned by two dowell projections on the plate. This insures correct mesh of the gear which drives the escapement with the pinion in the escapement. Grasp the right-hand plate of the escapement with a pair of flat-nosed pliers and carefully pull the escapement off of the dowels.

CAUTION: Always let down reroll spring before attempting to remove escapement.

f. CHART TIMING REGULATION: To regulate the hour-feed timing, move the regulator lever either up to make the drive run faster, or down to make it run slower. The regulator lever is visible through the slot in the front instruction plate. Although not all escapements respond alike, a movement of one division on the regulator scale affects the timing approximately four minutes a day. The regulation of chart speed on minute feeds is accomplished by turning the small screw located above the control lever on the escapement. The direction to turn for a faster or slower adjustment is shown by the arrows. This adjustment is very sensitive. Turn the screw slightly, permit mechanism to reach full speed, and note the effect on chart speed by using a timepiece and measuring how much chart is fed during a given period.

3.5.3 Motor-Wound Spring

a. The power to wind the mainspring of this type of drive is supplied by an internal induction motor. Another identical motor rerolls the used record chart as required. Both motors are energized periodically by means of a cam-operated switch. At any standard hour feed, the motor-wound spring drive will operate for five hours without electrical power.

NOTE: Should actuation of the cam-operated switch result in undesirable electrical interference, connect a .25mfd @ 600V capacitor in parallel with a 2000 ohm, 10-watt resistor across the switch terminals.

b. Before undertaking any repair work on this chart drive, the springs must be completely unwound. Failure to unwind the springs will release power suddenly and damage the chart drive. To unwind the mainspring, first turn off the power supply switch, then remove the instruction plate from the front of the drive. Next, find the copper colored detent located below the power switch on the inside of the right sideplate. Push in on the tail of this detent and allow the spring to unwind until the gearing stops turning. This spring unwinds rather slowly, so be sure to allow enough time for it to become completely unwound.

c. The reroll storage spring must also be unwound before removing the reroll train. Let the reroll roller turn slowly in the hand until the spring is completely run down.

d. The escapements used in motor-wound chart drives are similar to those used in hand-wound chart drives. Refer to servicing procedures in the "Hand-Wound Spring" section.

3.5.4 Phantom

a. The phantom chart drive is propelled by a source of power external to the drive. This external source is commonly a self-powered chart drive installed in one side of a twin recorder;the phantom drive is installed in the other side and is directly coupled to the powered drive.

b. When the application of a phantom drive requires that it be driven from some external shaft or motor instead of a powered chart drive, the driving member should be attached to the coupling shaft by means of a flexible coupling. The ends of the coupling shaft are fitted with a ball and cross pin which engages the slotted coupling head. Esterline Angus can furnish a variety of couplings or simply a coupling head so that the user may make up his own coupling shaft for a specific application.

c. All phantom drives have their own power for rerolling the used record chart. Two types are used: electric reroll and spring reroll. In phantom drives with electric reroll, reroll

power is provided by an internal induction motor which winds a storage spring. The spring transmits the power to the reroll. When the power to the reroll motor fails, the reroll storage spring has the capacity to wind up eighteen inches of used chart.

d. The reroll gear train may be replaced as a complete unit; or, the reroll storage spring only may be replaced. In either case, be sure to let down the reroll spring before attempting disassembly. With power off, hold the chart reroll roller in the hand and let it revolve slowly until it no longer turns. Damage may result if disassembly is attempted with energy stored in the spring.

e. In phantom drives with spring reroll, reroll power is supplied by internal hand-wound springs. The spring and reroll train assemblies are similar to those used in hand-wound spring drives. See "Unwinding the Springs" and "Replacing the Springs" under the "Hand-Wound Spring" section for servicing procedures.

3.5.5 Selsyn

a. Selsyn chart drives are operated by a General Electric (120 volts, 60Hz) Selsyn receiver. Power to operate the reroll of a selsyn drive is provided by a separate induction motor which winds a storage spring. This spring transmits power to the reroll roller.

b. The reroll gear train may be replaced as a complete unit; or, the reroll storage spring assembly only may be replaced. In either case, be sure to let down the reroll spring before attempting disassembly. With power off, hold the chart reroll roller in the hand and let it revolve slowly until it no longer turns. Damage may result if disassembly is attempted with energy stored in the spring. Refer to the separate supplement supplied with this manual for complete instructions on selsyn devices.

3.6 DISASSEMBLY

a. The chart drive assembly may be removed from the instrument case as a single unit except for recorders having rectigraph writing systems. For these recorders, the entire chassis must be removed; refer to the disassembly instructions in Part C of this manual for removal procedures.

WARNING: Remove power from instrument before disassembling or servicing.

b. Removal Procedures:

(1) Open the case cover or door and see that the chart drive is off.

CAUTION: Before attempting to remove the chart drive from a twin case, the drive coupling must be disconnected by pushing the coupling endwise as far as it will go. If pushed to the right, the left-hand unit may be removed. Do not pull the drive out at an angle to disconnect the coupling. This may damage both the drive and the coupling.

(2) From the front of the instrument, remove the four screws securing the chart drive at each corner of its rear mounting plate.

NOTE: When applicable, disconnect external drive couplings and raise or remove the writing elements.

(3) Lift the entire drive assembly out from the front of the case.

CAUTION: On electrical drives, unplug the lead connector(s) at the rear of the drive before attempting to completely remove the assembly.

3.7 TROUBLESHOOTING

The simplified troubleshooting guide presented in Table B7 may be used when minor chart drive troubles occur in the field. This table describes the most common troubles, lists the most frequent causes, and suggests the most likely remedy procedures. Refer to Part C of this manual for troubleshooting instructions dealing with other systems of the recorder.

3.8 REPLACEMENT PARTS

All parts for Series "A" chart drives are made available directly from Esterline Angus. When ordering parts, always give part numbers and instrument serial number. Refer to the illustrations in this manual for parts identification.

TABLE B7

CHART DRIVE TROUBLESHOOTING GUIDE

TROUBLE SYMPTOM	PROBABLE CAUSE	SUGGESTED REMEDY
Drive inoperative	Improper adjustment	See that levers or switches are properly set (refer to para. 2.6).
	Change gears incorrectly installed.	See that gear hub engages shaft (refer to para. 2.5b).
Drive inoperative (Spring types only)	Loss of power	See that spring is properly wound (refer to para. 2.6.1d).
Drive inoperative Electric types only).	Loss of power	Check power source, connectors, wiring, switch, and motor. (See Figure B11.)
Drive inoperative (Phantom types only).	Loss of power	Check driving source and mechanical couplings.
Reroll inoperative (drive functions).	Loss of power	Check reroll power source.(See Figure B11.)
	Bent disk on left end of reroll roller.	Straighten disk or replace roller assembly.
Hour-minute shift inoperative (manual type).	Defective shift spring	Remove instruction plate and check spring. Replace if necessary.
Hour-minute shift inoperative (electric type).	Loss of power.	Check power source, wiring, connections, and shift coil.(See Figure B11.)
Chart speeds are uneven (erratic).	Change gears incorrectly installed or binding.	See that gears engage shafts and that nuts are tight. Replace gears if bent or broken.
	Defective power source (Electric drives only)	Check power source and connections. (See Figure B11.)
Chart speeds are too fast or too slow.	Improper timing regulation (Escapement drives only).	Adjust timing regulation (refer to para. 3.5.2f).
	Incorrect power source (Synchronous drives only).	Check voltage and frequency ratings. (See Data Sheet).
Paper will not completely thread into drive when charting.	Threading path obstructed	Remove small bits of paper which may collect under rear of chart feeder and guides. Check clearance of chart feeder.
Leading edge of holes in chart paper tear	Chart paper binding	See that supply arbor turns freely and that chart is correctly installed.
Chart paper wrinkles	Chart guides not aligned properly.	Adjust chart guides (refer to para. 3.3b).
	Improper reroll action	Straighten paper on reroll roller and check reroll power source.
Excessive noise from drive.	Mechanical part binding, loose, or broken.	Check all moving parts. Replace if necessary.
	Lack of lubricant	Follow lubricating instructions in para. 3.2.3.

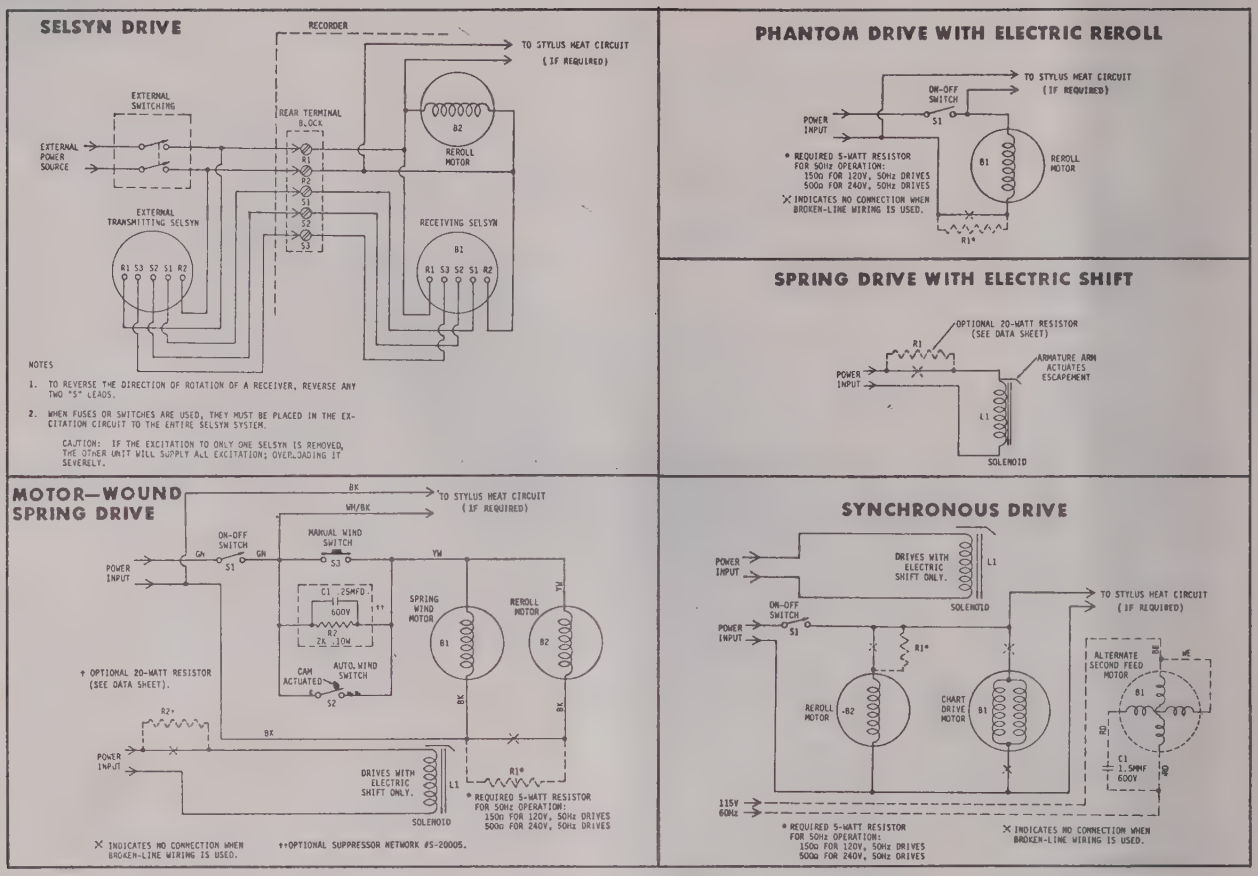
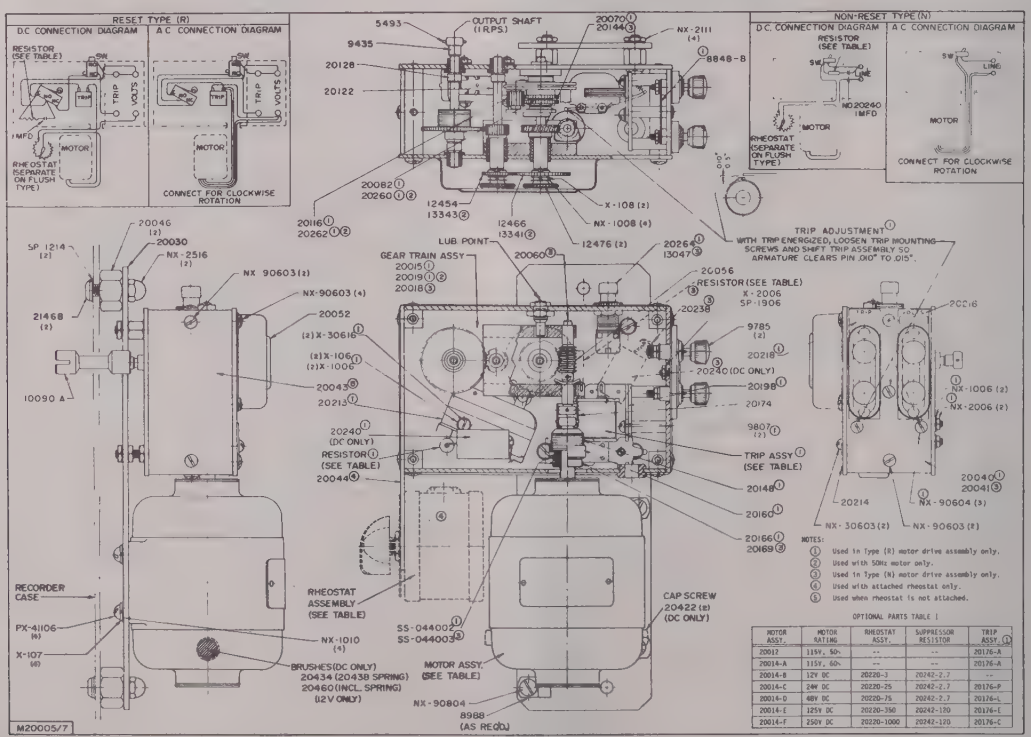

SELSYN DRIVE
RECORDER
TO STYLUS HEAT CIRCUIT (IF REQUIRED)
EXTERNAL SWITCHING
REAR TERMINAL BLOCK
EXTERNAL POWER SOURCE
REROLL MOTOR
EXTERNAL TRANSMITTING SELSYN
RECEIVING SELSYN
NOTES
1. TO REVERSE THE DIRECTION OF ROTATION OF A RECEIVER, REVERSE ANY TWO "S" LEADS.
2. WHEN FUSES OR SWITCHES ARE USED, THEY MUST BE PLACED IN THE EXCITATION CIRCUIT TO THE ENTIRE SELSYN SYSTEM.
CAUTION: IF THE EXCITATION TO ONLY ONE SELSYN IS REMOVED, THE OTHER UNIT WILL SUPPLY ALL EXCITATION; OVERLOADING IT SEVERELY.
PHANTOM DRIVE WITH ELECTRIC REROLL
TO STYLUS HEAT CIRCUIT (IF REQUIRED)
ON-OFF SWITCH
POWER INPUT
REROLL MOTOR
* REQUIRED 5-WATT RESISTOR FOR 50Hz OPERATION: 150Ω FOR 120V, 50Hz DRIVES 500Ω FOR 240V, 50Hz DRIVES
X INDICATES NO CONNECTION WHEN BROKEN-LINE WIRING IS USED.
SPRING DRIVE WITH ELECTRIC SHIFT
OPTIONAL 20-WATT RESISTOR (SEE DATA SHEET)
ARMATURE ARM ACTUATES ESCAPEMENT
SOLENOID
MOTOR—WOUND SPRING DRIVE
TO STYLUS HEAT CIRCUIT (IF REQUIRED)
MANUAL WIND SWITCH
SPRING WIND MOTOR
CAM ACTUATED
AUTO-WIND SWITCH
DRIVES WITH ELECTRIC SHIFT ONLY.
† OPTIONAL 20-WATT RESISTOR (SEE DATA SHEET).
* REQUIRED 5-WATT RESISTOR FOR 50Hz OPERATION: 150Ω FOR 120V, 50Hz DRIVES 500Ω FOR 240V, 50Hz DRIVES
X INDICATES NO CONNECTION WHEN BROKEN-LINE WIRING IS USED.
††OPTIONAL SUPPRESSOR NETWORK #S-20005.
SYNCHRONOUS DRIVE
DRIVES WITH ELECTRIC SHIFT ONLY.
TO STYLUS HEAT CIRCUIT (IF REQUIRED)
ALTERNATE SECOND FEED MOTOR
REROLL MOTOR -82
CHART DRIVE MOTOR
115V 60Hz
* REQUIRED 5-WATT RESISTOR FOR 50Hz OPERATION: 150Ω FOR 120V, 50Hz DRIVES 500Ω FOR 240V, 50Hz DRIVES
X INDICATES NO CONNECTION WHEN BROKEN-LINE WIRING IS USED.

Figure B11. Chart Drive Power Wiring Diagrams.


RESET TYPE (R)
D.C. CONNECTION DIAGRAM
A.C. CONNECTION DIAGRAM
NON-RESET TYPE (N)
OUTPUT SHAFT (1 RPS)
GEAR TRAIN ASSY
LUB POINT
TRIP ADJUSTMENT
WITH TRIP ENERGIZED, LOOSEN TRIP MOUNTING SCREWS AND SHIFT TRIP ASSEMBLY SO ARMATURE CLEARS PIN .010" TO .015".
RESISTOR (SEE TABLE)
RHEOSTAT (SEPARATE ON FLUSH TYPE)
CONNECT FOR CLOCKWISE ROTATION
TRIP ASSY (SEE TABLE)
RECORDER CASE
RHEOSTAT ASSEMBLY (SEE TABLE)
MOTOR ASSY (SEE TABLE)
BRUSHES(DC ONLY) 20434 (20438 SPRING) 20460 (INCL. SPRING) (12V ONLY)
CAP SCREW 20422 (2) (DC ONLY)
NOTES:
1. Used in Type (R) motor drive assembly only.
2. Used with 50Hz motor only.
3. Used in Type (N) motor drive assembly only.
4. Used with attached rheostat only.
5. Used when rheostat is not attached.
OPTIONAL PARTS TABLE I
M20005/7

MOTOR ASSY.	MOTOR RATING	RHEOSTAT ASSY.	SUPPRESSOR RESISTOR	TRIP ASSY. (1)
20017	115V, 50-	--	--	20176-A
20014-A	115V, 60-	--	--	20176-A
20014-B	12V DC	20220-3	20242-2.7	--
20014-C	24V DC	20220-25	20242-2.7	20176-P
20014-D	48V DC	20220-75	20242-2.7	20176-L
20014-E	125V DC	20220-350	20242-130	20176-E
20014-F	250V DC	20220-1000	20242-130	20176-C

Figure B12. External Motor Attachments (Optional).

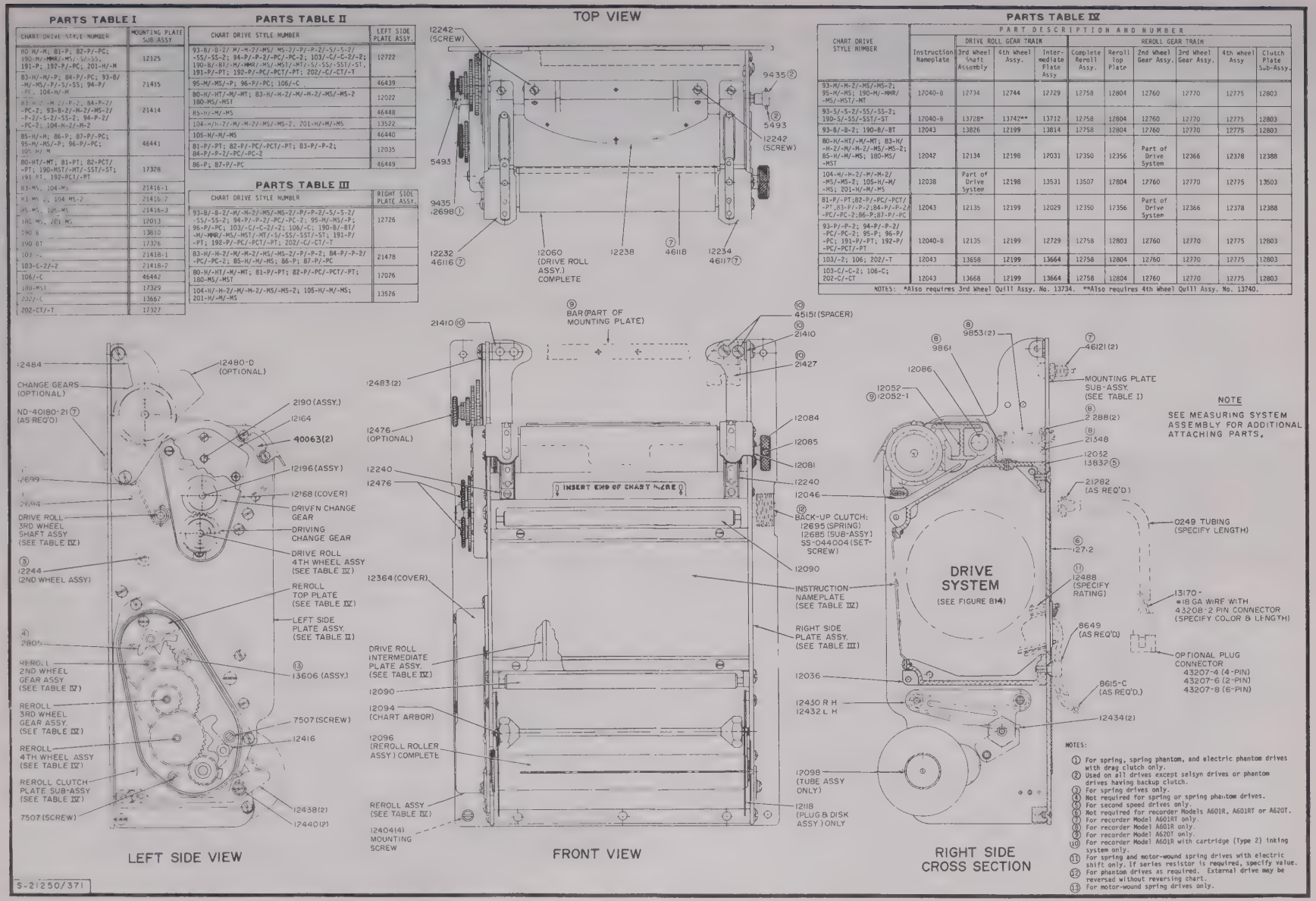

PARTS TABLE I
CHART DRIVE STYLE NUMBER | MOUNTING PLATE SUB ASSY
80-H/-M; 81-P; 82-P/-PC; 190-M/-MMR/-MS/-SS-SS; 191-P; 192-P/-PC; 201-H/-M | 12125
83-H/-M/-P; 84-P/-PC; 93-8/-M/-MS/-P/-S/-SS; 94-P/-PC; 104-H/-M | 21415
83-H/-M; 84-P-2; 84-P-2/-PC-2; 93-B-2/-M-2/-MS-2/-P-2/-S-2/-SS-2; 94-P-2/-PC-2; 104-H-2/-M-2 | 21414
85-H/-M; 86-P; 87-P/-PC; 95-M/-MS/-P; 96-P/-PC; 105-H/-M | 46441
80-MT/-MT; 81-PT; 82-PCT/-PT; 190-MST/MT/-SST/-ST; 191-PT; 192-PCT/-PT | 17328
83-MS; 104-MS | 21416-1
83-MS-2; 104-MS-2 | 21416-2
85-MS; 105-MS | 21416-3
180-MS; 201-MS | 12013
190-B | 13810
190-BT | 17326
103-C | 21418-1
103-C-2/-2 | 21418-2
106/-C | 46442
180-MST | 17329
202/-C | 13662
202-CT/-T | 17327
PARTS TABLE II
CHART DRIVE STYLE NUMBER | LEFT SIDE PLATE ASSY.
93-B/-B-2/-M/-M-2/-MS/-MS-2/-P/-P-2/-S/-S-2/-SS/-SS-2; 94-P/-P-2/-PC/-PC-2; 103/-C/-C-2/-2; 190-B/-BT/-M/-MMR/-MS/-MST/-MT/-S/-SS/-SST/-ST, 191-P/-PT; 192-P/-PC/-PCT/-PT; 202/-C/-CT/-T | 12722
95-M/-MS/-P; 96-P/-PC; 106/-C | 46439
80-H/-MT/-M/-MT; 83-H/-M-2/-M/-M-2/-MS/-MS-2 180-MS/-MST | 12022
85-H/-M/-MS | 46448
104-H/-M-2/-M/-M-2/-MS/-MS-2, 201-H/-M/-MS | 13522
105-M/-M/-MS | 46440
81-P/-PT; 82-P/-PC/-PCT/-PT; 83-P/-P-2; 84-P/-P-2/-PC/-PC-2 | 12035
86-P; 87-P/-PC | 46449
PARTS TABLE III
CHART DRIVE STYLE NUMBER | RIGHT SIDE PLATE ASSY.
93-B/-B-2/-M/-M-2/-MS/-MS-2/-P/-P-2/-S/-S-2/-SS/-SS-2; 94-P/-P-2/-PC/-PC-2; 95-M/-MS/-P; 96-P/-PC; 103/-C/-C-2/-2; 106/-C; 190-B/-BT/-M/-MMR/-MS/-MST/-MT/-S/-SS/-SST/-ST; 191-P/-PT; 192-P/-PC/-PCT/-PT; 202/-C/-CT/-T | 12726
83-H/-M-2/-M/-M-2/-MS/-MS-2/-P/-P-2; 84-P/-P-2/-PC/-PC-2; 85-H/-M/-MS; 86-P; 87-P/-PC | 21478
80-H/-HT/-M/-MT; 81-P/-PT; 82-P/-PC/-PCT/-PT; 180-MS/-MST | 12026
104-H/-M-2/-M/-M-2/-MS/-MS-2; 105-H/-M/-MS; 201-H/-M/-MS | 13526
TOP VIEW
12242 (SCREW)
9435 ②
5493
12242 (SCREW)
5493
9435 ②
2698 ①
12232 46116 ⑦
12060 (DRIVE ROLL ASSY.) COMPLETE
12238
⑦ 46118
12234 46117 ⑦
PARTS TABLE IV
CHART DRIVE STYLE NUMBER | PART DESCRIPTION AND NUMBER
Instruction Nameplate | DRIVE ROLL GEAR TRAIN: 3rd Wheel Shaft Assembly | 4th Wheel Assy. | Intermediate Plate Assy | REROLL GEAR TRAIN: Complete Reroll Assy. | Reroll Top Plate | 2nd Wheel Gear Assy. | 3rd Wheel Gear Assy. | 4th Wheel Assy | Clutch Plate Sub-Assy.
93-M/-M-2/-MS/-MS-2; 95-M/-MS; 190-M/-MMR/-MS/-MST/-MT | 12040-B | 12734 | 12744 | 12729 | 12758 | 12804 | 12760 | 12770 | 12775 | 12803
93-S/-S-2/-SS/-SS-2; 190-S/-SS/-SST/-ST | 12040-B | 13728* | 13742** | 13712 | 12758 | 12804 | 12760 | 12770 | 12775 | 12803
93-B/-B-2; 190-B/-BT | 12043 | 13826 | 12199 | 13814 | 12758 | 12804 | 12760 | 12770 | 12775 | 12803
80-H/-HT/-M/-MT; 83-H/-M-2/-M/-M-2/-MS/-MS-2; 85-H/-M/-MS; 180-MS/-MST | 12042 | 12134 | 12198 | 12031 | 12350 | 12356 | Part of Drive System | 12366 | 12378 | 12388
104-H/-M-2/-M/-M-2/-MS/-MS-2; 105-H/-M/-MS; 201-H/-M/-MS | 12038 | Part of Drive System | 12198 | 13531 | 13507 | 12804 | 12760 | 12770 | 12775 | 13503
81-P/-PT; 82-P/-PC/-PCT/-PT; 83-P/-P-2; 84-P/-P-2/-PC/-PC-2; 86-P; 87-P/-PC | 12043 | 12135 | 12199 | 12029 | 12350 | 12356 | Part of Drive System | 12366 | 12378 | 12388
93-P/-P-2; 94-P/-P-2/-PC/-PC-2; 95-P; 96-P/-PC; 191-P/-PT; 192-P/-PC/-PCT/-PT | 12040-B | 12135 | 12199 | 12729 | 12758 | 12803 | 12760 | 12770 | 12775 | 12803
103/-2; 106; 202/-T | 12043 | 13658 | 12199 | 13664 | 12758 | 12804 | 12760 | 12770 | 12775 | 12803
103-C/-C-2; 106-C; 202-C/-CT | 12043 | 13668 | 12199 | 13664 | 12758 | 12804 | 12760 | 12770 | 12775 | 12803
NOTES: *Also requires 3rd Wheel Quill Assy. No. 13734. **Also requires 4th Wheel Quill Assy. No. 13740.
LEFT SIDE VIEW
12484
CHANGE GEARS (OPTIONAL)
12480-D (OPTIONAL)
ND-40180-21 ⑦ (AS REQ'D)
2190 (ASSY.)
12164
40063(2)
12196 (ASSY)
2699
2694
12168 (COVER)
DRIVEN CHANGE GEAR
DRIVE ROLL 3RD WHEEL SHAFT ASSY (SEE TABLE IV)
DRIVING CHANGE GEAR
③ 12244 (2ND WHEEL ASSY)
DRIVE ROLL 4TH WHEEL ASSY (SEE TABLE IV)
REROLL TOP PLATE (SEE TABLE IV)
LEFT SIDE PLATE ASSY. (SEE TABLE II)
④ 2805
③ 13606 (ASSY.)
REROLL 2ND WHEEL GEAR ASSY (SEE TABLE IV)
REROLL 3RD WHEEL GEAR ASSY (SEE TABLE IV)
7507 (SCREW)
12416
REROLL 4TH WHEEL ASSY (SEE TABLE IV)
REROLL CLUTCH PLATE SUB-ASSY (SEE TABLE IV)
7507 (SCREW)
12438(2)
12440(2)
S-21250/371
FRONT VIEW
⑨ BAR (PART OF MOUNTING PLATE)
⑩ 45151 (SPACER)
21410 ⑩
⑩ 21410
⑩ 21427
12483(2)
12476 (OPTIONAL)
12084
12085
12081
12240
12476
INSERT END OF CHART HERE
12240
12046
⑫ BACK-UP CLUTCH: 12695 (SPRING) 12685 (SUB-ASSY.) SS-044004 (SET-SCREW)
12090
INSTRUCTION NAMEPLATE (SEE TABLE IV)
12364 (COVER)
RIGHT SIDE PLATE ASSY. (SEE TABLE III)
DRIVE ROLL INTERMEDIATE PLATE ASSY. (SEE TABLE IV)
12090
12036
12094 (CHART ARBOR)
12430 R H
12432 L H
12096 (REROLL ROLLER ASSY.) COMPLETE
12098 (TUBE ASSY ONLY)
12118 (PLUG & DISK ASSY.) ONLY
REROLL ASSY (SEE TABLE IV)
12404(4) MOUNTING SCREW
RIGHT SIDE CROSS SECTION
⑧ 9853(2)
⑧ 9861
⑦ 46121(2)
12086
MOUNTING PLATE SUB-ASSY. (SEE TABLE I)
12052
⑨ 12052-1
⑧ 2 288(2)
⑧ 21348
12032
13832 ⑤
21282 (AS REQ'D)
0249 TUBING (SPECIFY LENGTH)
⑥ 127.2
DRIVE SYSTEM (SEE FIGURE B14)
⑪ 12488 (SPECIFY RATING)
13170- #18 GA WIRE WITH 43208-2 PIN CONNECTOR (SPECIFY COLOR & LENGTH)
8649 (AS REQ'D)
OPTIONAL PLUG CONNECTOR 43207-4 (4-PIN) 43207-6 (2-PIN) 43207-8 (6-PIN)
8615-C (AS REQ'D.)
12434(2)
NOTE
SEE MEASURING SYSTEM ASSEMBLY FOR ADDITIONAL ATTACHING PARTS.
NOTES:
① For spring, spring phantom, and electric phantom drives with drag clutch only.
② Used on all drives except selsyn drives or phantom drives having backup clutch.
③ For spring drives only.
④ Not required for spring or spring phantom drives.
⑤ For second speed drives only.
⑥ Not required for recorder Models A601R, A601RT or A620T.
⑦ For recorder Model A601RT only.
⑧ For recorder Model A601R only.
⑨ For recorder Model A620T only.
⑩ For recorder Model A601R with cartridge (Type 2) inking system only.
⑪ For spring and motor-wound spring drives with electric shift only. If series resistor is required, specify value.
⑫ For phantom drives as required. External drive may be reversed without reversing chart.
⑬ For motor-wound spring drives only.

Figure B13. Chart Drive Parts Location Diagram.

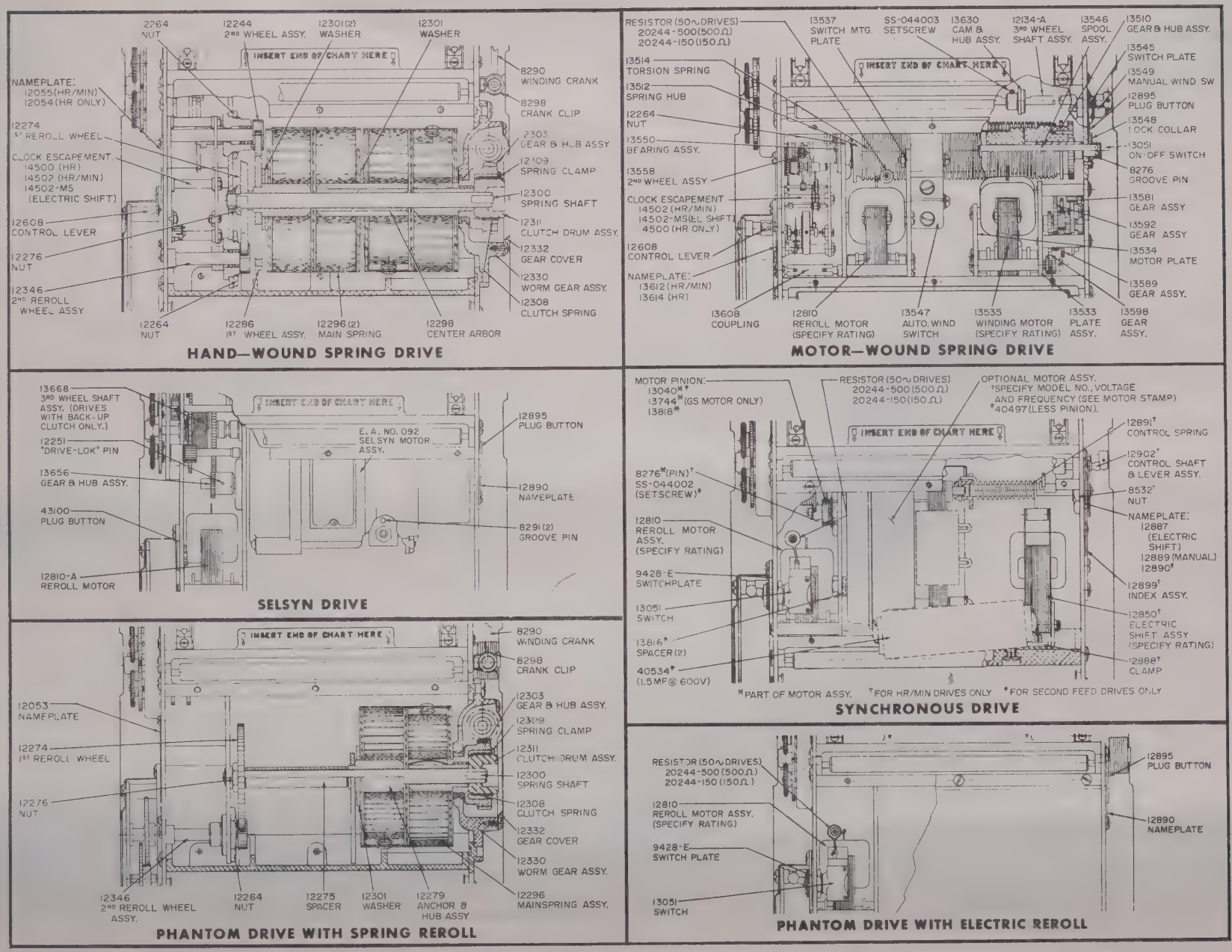


Figure B14. Drive Systems Diagram.

PART C

MEASURING AND RECORDING SYSTEM

SECTION 1 — DESCRIPTION

1.1 INTRODUCTION

a. This part of the manual includes technical descriptions, operating procedures, and maintenance instructions for various measuring and recording systems employed in Model A601C Recorders. Refer to the Data Sheet in the envelope at the back of this manual for the specific type of system supplied within the instrument.

NOTE: Optional systems will be found in PART D of this manual when applicable. Refer to supplemental instructions for additional model variations.

b. The Model A601C is designed to graphically record analog information on a 6" strip chart with calibrated curvilinear span. Almost any analog data represented by electrical signals within metering range of the instrument may be recorded.

c. Electrical signals that are outside the range limits of the instrument may also be recorded by using signal-conditioning devices--such as current or potential transformers, shunts, resistance multipliers, rectifier networks, and amplifiers. Many types of transducers may be used with the instrument to convert various phenomena into useful analog signals. For additional information, consult your local sales representative or the Customer Service Department of Esterline Angus.

1.2 GENERAL DESCRIPTION

a. Several different internal measuring systems are available in these recorders. Standard systems include: DC Ammeters, Milliammeters and Microammeters;DC Voltmeters and Millivoltmeters; rectifier type AC Voltmeters, Ammeters, and Millammeters;AC and DC Expanded-Scale Voltmeters; as well as Multipurpose and Speed Recorders. Multirange systems are also available upon special order.

b. Each measuring system incorporates a galvanometric meter movement as shown in Fig. C1. This permanent-magnet, moving-coil assembly consists of an armature coil suspended in a fixed magnetic field which is formed by two U-shaped magnets. The armature coil is wound on a metal frame and is supported at the lower end by a jewel and pivot arrangement to minimize friction.

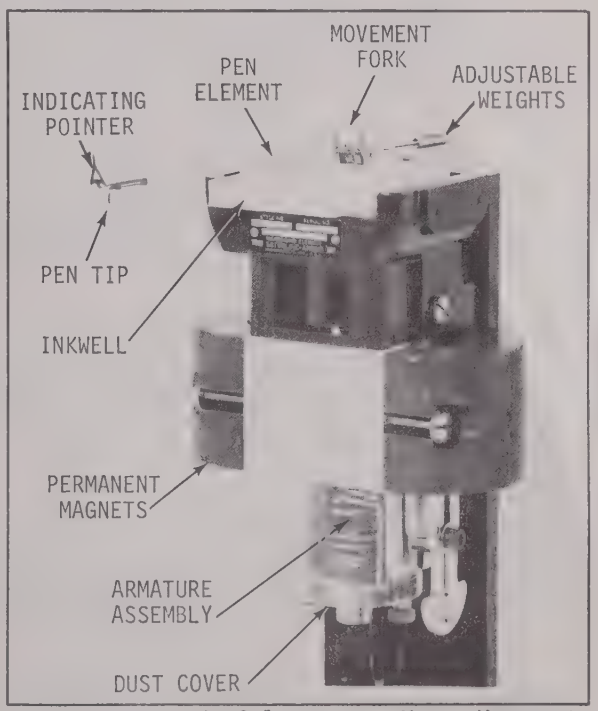


Figure C1. Basic Galvanometer Meter Movement.

c. As current flows in the armature, an electro-magnetic field is developed around the coil; this field automatically attempts to move itself out of the fixed field, torque is generated, and the armature turns on its axis. Rotation of the coil is opposed by a pair of

counter-wound spiral springs which are connected to the lower part of the armature staff. These springs return the coil to a fixed zero position when no current is flowing. The degree of rotation depends directly upon the magnitude of current flowing in the armature coil.

d. In addition, the movement has an inherent damping characteristic resulting from eddy currents induced in the moving-coil frame. These currents produce a "bucking" magnetic field that tends to minimize overshoot and oscillation. A pen-and-ink system is employed as a method of recording on the chart paper. The direct-acting pen rides in a pen fork which is attached to the top of the moving armature.

1.3 SPECIFICATIONS

TABLE C1. DC MILLIAMMETERS

Single Range Instruments

Range In MA	Measuring Element Number	Full Scale Volts[a]	Resistance In Ohms	Power Consumption In Milliwatts	Ohms In External Circuit for Critical Damping	Response Time (Seconds, One Way)					
						Critically Damped	With External Circuit Resistance of				
							10 Ohms	100 Ohms	1,000 Ohms	10,000 Ohms	100,000 Ohms
0-1	424	1.4	1400	1.4	50,000	0.5	5.0	4.0	3.0	1.0	0.5
0-2	424	7.0	3500	14.0			1.2	1.2	1.2	1.0	1.0
0-3	424	7.0	2330	21.0			1.2	1.2	1.2	1.1	1.1
0-5	421	0.35	70	1.7	4,000	0.5	4.0	3.0	0.8	0.5	0.5
0-10	421	2.0	200	20.0			1.2	1.1	1.0	0.8	
0-25	421	2.0	80	50.0			1.2	1.1	1.1	1.0	
0-50	422	0.05	1.0	2.50	25	0.5	1.0	0.5	0.5	0.5	
0-100	422	0.20	2.0	20.0			1.0	0.8	0.8		
0-150	423	0.018	0.12	2.7	2	0.5	0.5	0.5	0.5		
0-250	423	0.1	0.40	25.0	over 10	0.5	0.5	0.5	0.5		
0-500	423	0.1	0.20	50.0			0.8	0.8	0.8		
0-1000	423	0.1	0.10	100.0			1.0	1.0			

Multi-range Instruments

The measuring element used in multi-range milliammeters is determined by the lowest range to be included. Where the lowest range is below 0-5 MA, the 424 measuring element is used. If the lowest range is 0-5 MA or higher, No. 421 is used. Measuring elements Nos. 422 and 423 are not used in multi-range instruments. Multi-range meters have only two terminals, the various ranges being obtained with a tap switch, usually mounted in the case.

Range In MA	Full Scale Volts[a]	Resistance In Ohms	Power Consumption In Milliwatts	Ohms In External Circuit For Critical Damping	Response Time (Seconds, One Way)					
					Critically Damped	With External Circuit Resistance of				
						10 Ohms	100 Ohms	1,000 Ohms	10,000 Ohms	100,000 Ohms
WITH NO. 424 (0-1 MA) ELEMENT										
0-1	1.4	1400	1.4	50,000	0.5 sec.	5	4	3	1.0	0.5
0-2	7	3500	14			1.2	1.2	1.2	1.0	1.0
0-3	7	2330	21			1.2	1.2	1.2	1.1	1.1
0-5	7	1400	35			1.2	1.2	1.2	1.2	1.2
0-10	7	700	70			1.2	1.2	1.2	1.2	
0-25	7	280	175			1.2	1.2	1.2	1.2	
0-50	7	140	350			1.2	1.2	1.2	1.2	
0-100	7	70	700			1.2	1.2	1.2		
WITH NO. 421 (0-5 MA) ELEMENT										
0-5	0.35	70	1.7	4,000	0.5 sec.	4	3	0.8	0.5	0.5
0-10	2	200	20			1.2	1.1	1.0	0.8	
0-25	2	80	50			1.2	1.1	1.0	1.0	
0-50	2	40	100			1.2	1.2	1.1	1.1	
0-100	2	20	200			1.2	1.2	1.2		
0-250	2	8	500			1.2	1.2	1.2		
0-500	2	4	1000			1.2	1.2	1.2		

a In those instances where there is objection to the voltage drop shown for those ranges above the basic range, direct shunting can be employed. This reduces the drop on all ranges to 1.4 volts on meters using basic element No. 424, and 0.35 volts on No. 421. Note, however, that response time is increased 3 to 5 seconds for all shunted ranges.

GENERAL CHARACTERISTICS

Scales—Supplied to match any standard chart. On multi-range meters, scale will match the lowest or the most used range.

Damping—Eddy current type; variable by adjustment of external circuit resistance.

Response Speed—See tables above.

Guaranteed Accuracy—1% of full scale current.

Zero—Normal calibration is left-hand zero. Shifting to center zero cuts in half the current for full scale in either direction. Center zero meters may be shifted to left-hand zero and operated up to full scale without overloading the measuring circuit.

Multi-ranges—No. 424 measuring element can be supplied with ranges between 0-1.0 MA and 0-1.0 ampere. No. 421 measuring element can be furnished with ranges from 0-5.0 MA to 0-2.0 amperes. Where the lowest range is 0-150 MA, use DC Ammeters and appropriate shunts. Voltage ranges can be combined with milliampere ranges in the same instrument.

Leads—None furnished. Lead resistance is not critical.

Binding Posts—Regularly furnished on portables.

Dielectric Test—Single range meters, 5000 volts; multi-range, 2500 volts, 60 cycles for one minute.

TABLE C2. DC AMMETERS/VOLTMETERS/MILLIVOLTMETERS

Standard Type	DC Ammeters Measuring Element No. 423	DC Millivolt-Voltmeters Measuring Element No. 423 Range		DC Voltmeters Measuring Element No. 421
	Range in MV	**Millivolts**	**Volts**	**Range in Volts**
Full-Scale Ranges (Optional)	0-50 0-100* 0-300 0-600 0-60 0-150 0-400 0-75 0-200 0-500 *Meter is direct-reading with standard E. A. 100 MV shunt.	0-50 0-200 0-60 0-300 0-75 0-400 0-100 0-500 0-150 0-600 Voltage ranges may be used for speed recorder applications.	0-1 0-50 0-2 0-100 0-5 0-150 0-10 0-300 0-25 0-600	0-2 0-30 0-500 0-3 0-50 0-600 0-5 0-60 0-750 0-7.5 0-75 0-800 0-10 0-100 0-1000§ 0-15 0-150 0-1200§ 0-20 0-200 0-1500§ 0-25 0-300
Leads	5 foot calibrated leads with all types.	5 foot calibrated leads with all types. Must be used on all ranges up to 1 volt.		Furnished only with portable type, 5 ft. long. Leads not calibrated.
Binding Posts	Not permissible.	Permissible on ranges above 0-1 volt.		May be supplied on portables instead of leads.
Multipliers	None required.	On ranges 125 V and above.		On ranges above 800 V.
Guaranteed Accuracy	1½% of full scale.	1½% of full scale.		1% of full scale.
Electrical Data	Left zero—150 MA full scale Center zero—75-0-75 MA	Left zero—6⅔ ohms per volt. Center zero—13⅓ ohms per volt.		Left zero—200 ohms per volt. Center zero—400 ohms per volt.
Special Ranges	Single range between 150 MA and 10 amp. self contained.	Any intermediate range.		Any intermediate range. 1000 ohms per volt can be furnished for ranges 0-7 to 0-800 volts. Milliampere ranges can also be furnished in addition to voltage ranges.
Shunts	Shunt rated other than 100 MV can be used with 100-MV meter, provided proper precautions are taken to prevent overloading shunt, if less than 100 MV. Shunt rating should usually be about 25% above full load current.			None

Shunt leads should not be switched unless all lead wire and switch are calibrated as a unit with the meter.
§When used on voltages above 800, one side of circuit must be grounded. Multiplier connections must be made to ungrounded line. Meter case and multiplier case must be grounded by means of the special terminals provided.

GENERAL CHARACTERISTICS

Scales—Supplied to match any standard chart.

Zero—Left-hand zero. Can be shifted to center zero. This cuts in half voltage and current for full scale deflection. Ammeter—Center zero meters can be shifted to left-hand zero but this may overload the shunt at full scale. Millivolt-Voltmeter and Voltmeter—Center zero meters must not be shifted to left-hand zero, unless such use is specified when ordering.

Multiranges—Nearly any combination of above or intermediate ranges.

Response Speed—Time required for pen to swing one way. Ammeter and Millivolt-Voltmeter—1 sec. for 100-MV range; 0.5 second for 300 MV range. Voltmeter—0.5 sec. ranges 0-15 V and above; 0-2 V range 1.25 sec.

Insulation Test—5000 volts, 60 cycles, for one minute.

Permissible Lead Lengths for Ammeters and Millivoltmeters * *

Range in MV	Maximum Allowable Resistance between Shunt and Meter (in ohms) for left-hand zero meter†	Corresponding Approximate Length in Feet (one way) of Average Copper wire leads at 30°C		
		No. 10	No. 8	No. 4
0-50	0.133	65	100	255
0-60	0.200	95	150	385
0-66⅔	0.244	115	185	470
0-75	0.300	145	230	580
0-100	0.467	225	355	900
0-125	0.633	305	485	1220
0-150	0.800	385	610	1540
0-200	1.133	545	860	2190

* *Based on a full-scale current of 0.150 ampere and a drop of 30 MV at meter terminals. Where longer leads are necessary a special measuring element can be furnished.

†For a center-zero meter, use lead data for left-hand zero meter having twice the full scale MV. Example: For a 100-0-100 MV meter, use lead data for 0-200 MV meter. In calculating resistance of leads, their average operating temperature must be allowed for. Standard calibration is on the basis of a lead temperature of 30° C. (86° F.)

TABLE C3
MULTI-PURPOSE RECORDERS

Measuring Element No. 425-R (50-800 cycles)

Ranges

(Single- or Multi-range)

AC Milli-ammeter	AC AMMETERS		VOLTMETERS (Approx. 10 ohms per volt AC, 20 ohms per volt DC)		
	Single Ranges Amperes	Double Ranges Amperes	AC	DC	
Milli-amperes			Volts	MV	Volts
0-50	0-1.0	0-1.0/2.0	0-50	0-100	0-1
	0-1.25	0-1.25/2.5	0-75	0-125	0-2
	0-2.0	0-2.0/4.0	0-100	0-150	0-5
	0-2.5	0-2.5/5.0	0-125	0-200	0-10
	0-4.0	0-5.0/10	0-150	0-300	0-25
	0-5.0		0-300	0-400	0-50
	0-10		0-600	0-500	0-100
			0-750	0-750	0-150
			0-800		0-300
					0-600
					0-800

Scales—Supplied to match any standard chart. Scale will match lowest or most used range.

Accuracy—AC: 2% of full scale on sine wave; 150/300/600 volts, 60 cycles 1%. DC: Millivolts 1½%; volts 1% of full scale.

Zero—Left-hand. Recorder has no polarity on AC ranges.

Leads—Two 5-foot leads furnished with portable recorders. Other case styles have screw terminals. Meters with a millivolt range require calibrated leads.

Dielectric Test—2500 volts, 60 cycles for one minute.

Overload Capacity—100% continuous overload on all current ranges; 10 times full scale for 1 second.

Burden—Less than 1.0 volt-ampere on current ranges. Sensitivity of AC voltage ranges is 10 ohms per volt; on DC voltage ranges sensitivity is 20 ohms per volt.

Current Transformers—Required above 50 MA and 5 amperes AC. Use only special split-core CT on 50 MA range.

Shunts—Required with 100 MV range.

Step-up Potential Transformer—Record low 60 cycle voltages with 5/15/30:150 volt 60 cycle transformer.

TABLE C4
DC MILLIVOLTMETERS/MICROAMMETERS (WITH AMPLIFIERS)

Scales - Supplied to match any standard chart.

Standard Ranges - 0-10MV to 0-99MV with 10MV Op Amp; 0-100MV to 0-1V with 100MV Op Amp.*

Optional Ranges - 0-10 μA to 0-1 MA (with shunts).

Input Impedance - 10 megohms (up to 1V range).

Source Impedance - Up to 10K ohms.

Accuracy - ±1% of full scale.

Response - 0.5 second (full span).

* 0-1MV Op Amp available.

Zero Stability - 3 microvolts per °F.

Temperature Range - +20° to +120°F.

Dielectric Test - 600V (RMS) for one minute between power terminals and case. 500V DC for one minute between signal input, power terminals and case.

Power Supply - 120V ±10%, 50/60Hz.

Leads - None furnished. Lead resistance not critical.

Terminals - Binding posts on portable recorders. Screw terminals on flush units.

Other Options - Special or Multirange meters. Self-contained battery or 400Hz operation. Consult factory.

TABLE C5. EXPANDED-SCALE VOLTMETERS

	Normal Response	Rapid Response
Ranges*	0- 90—130 V AC 0-180—260 V AC 0-360—520 V AC 0-100—140 V AC 0-200—280 V AC 0-400—560 V AC 0- 24— 32 V DC**	0- 90—130 V AC 0-180—260 V AC 0-360—520 V AC 0-100—140 V AC 0-200—280 V AC 0-400—560 V AC
Accuracy	1% of mid-scale voltage	1% of mid-scale voltage
Frequency Limits***	50-60 cycles	50-60 cycles
Current at Full Scale	150 MA	225 MA
Response	1/3 second for full voltage reading	1/10 second for full voltage reading
Ambient Temperature Range	+20° to +120° F	+20° to +120° F

*Two or three ranges may be combined in one instrument, provided, higher ranges are even multiples of lowest range.
**Recording DC voltage having AC ripple content in excess of 2% requires special consideration.
***Calibrations for higher frequencies (such as 400 cycles) can usually be furnished at no extra charge.

NOTE: All other characteristics are the same as those given for standard voltmeters.

SECTION 2 — OPERATION

2.1 GENERAL

a. Do not attempt to put this instrument into operation until all instructions have been thoroughly studied. Failure to make proper connections or to make necessary checks and adjustments may result in unsatisfactory operation or damage to the instrument.

b. To prepare the measuring and recording system for operation, all packing materials must be removed, proper electrical connections made, the inking system primed, and adjustments performed for an accurate analog readout. Instructions for installing chart paper and operating the chart drive are included in PART B of this manual. Refer to the manual appendix (PART D) for instructions covering special optional systems.

2.2 ELECTRICAL CONNECTIONS

2.2.1 Power Inputs

a. External connections for electric chart drives and for other optional recorder accessories are made to terminals located on the rear of the instrument case. Portable recorders however are equipped with a power cord when an electric drive is supplied. Typical terminal locations are shown in Fig. C2.

CAUTION: Always check input ratings before making connections to instrument.

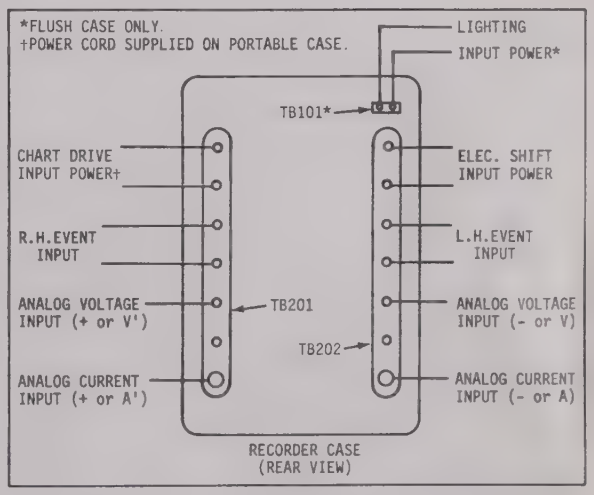


Figure C2. Typical Terminal Locations for Standard Recorders.

b. External connection procedures for all standard accessories are shown in Table C6. Terminals on the recorder are identified with specific input designations. If complete ratings are not specified on the terminal blocks, refer to the instrument Data Sheet, or to supplementary information in the appendix (PART D) of this manual. Make sure that all connections are clean and tight.

TABLE C6

EXTERNAL POWER CONNECTIONS

OPTIONAL ACCESSORY	CONNECT TO TERMINALS MARKED:
Electric Chart Drive.	(Chart Drive)
Electric Drive with Amplifier.	(Power Supply)
Electric (Hr.-Min.) Shift.	(Shift)
Selsyn Chart Drive.	(See Fig.B11)
External Motor Drive.	(M)(M')*
External Motor "Trip".**	(T)(T')*
Left-Hand Event Pen.	(L.H.Pen)
Right-Hand Event Pen.	(R.H.Pen)
Amplifier Power Supply (Separate).	(Ampl.)
Internal Lighting (Flush Case).	(TB101)
Case Ground.	(Ground)

* For Wall and Switchboard Cases Only.
** Do Not Apply Power to "Trip" Terminals; Only a Contact Closure Is Required.

TABLE C7

EXTERNAL ANALOG CONNECTIONS

ANALOG MEASURING SYSTEM	CONNECT TO TERMINALS MARKED:
DC Microammeter, Milliammeter, Ammeter, Millivoltmeter, Voltmeter, Expanded-Scale Voltmeter or Speed Recorder.	(-)(+)
AC Milliammeter or Ammeter.	(A)(A')
AC Voltmeter or Expanded-Scale Voltmeter.	(V)(V')
Standard Multipurpose Meters:	
DC Millivolts	(+MV)(-DC)
DC Volts	(+Volts)(-DC)
AC Volts	(AC Volts)(±AC)
AC Milliamps	(AC MA)(±AC)
AC Amps	(AC AMPS)(±AC)

NOTE: See Appendix (PART D) for other special connections.

Prime symbol (') indicates positive instantaneous polarity.

2.2.2 Analog Inputs

a. External input connections for the analog system are made to terminals located on the rear of the recorder case. Typical connection diagrams are shown in Fig. C3. Terminals are marked with an identifying letter, input title or polarity symbol. If complete ratings are not specified, refer to the instrument Data Sheet or to supplementary information in the appendix (PART D) of this manual.

> CAUTION: Always check polarity and input ratings before making connections. A series resistance, current shunt, or step-down transformer may be required.

b. Analog connection procedures for standard recorders are given in Table C7. Make sure that all connections are clean and tight. The positive instantaneous polarity of an AC input is identified by a prime mark ('). This mark will appear after the letter designation on the terminal block.

c. A precise amount of damping has been designed into each galvanometric movement employed in these recorders. For units with internal amplifiers, pen response speed will not normally be affected by characteristics of the circuit in which the recorder is operated. Without an amplifier, however, damping, and consequently response speed, will vary considerably with external circuit resistance. (See measuring system specification tables).

d. Current leads are furnished for recorders used with external shunts, and are marked with the instrument serial number. Recorders with current leads are calibrated for the correct measuring-circuit voltage drop AT THE SHUNT END OF THE LEADS; and only these leads should be used in the current circuits. All other connections for power circuits should be made with No. 14 wire or larger.

e. All portable instruments, with the exception of recording milliammeters and microammeters, are furnished with a set of leads. These leads have taper plugs on the instrument end and open-spade terminals on the other end. Keep the plugs and terminals clean to insure good contact. All recorder terminals for plug connections are threaded inside so that the instrument can be fitted with binding posts. These posts may be obtained from Esterline Angus. An order request should include the serial number of the instrument on which the posts will be used.

> CAUTION: Binding Posts should not be used on any recorder operated from shunts. Only the calibrated leads furnished with the recorder should be used for this purpose.

f. If the recorder is to be operated in a circuit with other instruments, Esterline Angus will provide information for recommended connections upon request. Care must be taken to connect current circuits in series and potential circuits in parallel. Refer to the Data Sheet for any electrical ratings not clearly marked on the input terminal blocks.

2.3 INKING INSTRUCTIONS

2.3.1 General

a. Esterline Angus ink is employed in the recorder to produce a permanent record on the chart paper. This writing fluid is especially formulated to satisfy the exacting requirements of recording instruments; and therefore, no other substitute should be used.

b. The recorder is shipped with the inking system in a dry state. As part of putting the instrument in operating condition, the pen element must be installed, the inkwell filled with ink, and the system primed in accordance with the instructions that follow.

> NOTE: Ink may begin to crystalize at low temperatures; therefore, heat must be provided within the instrument if temperatures remain below 20°F.

c. Prior to making the inking system operational, a new chart should be installed by following steps given in the charting instructions; and also see that all shipping materials have been removed from the instrument.

d. Unpack the accessory kit supplied with the recorder. This kit should include the following items:

1 - Two-ounce bottle of ink
1 - Inkwell filler syringe
1 - Pen-filler syringe
1 - Pen-point cleaner

> NOTE: Two accessory kits are supplied with each twin-case instrument. Replacement kits are available under Part No. 5785-(specify ink color).

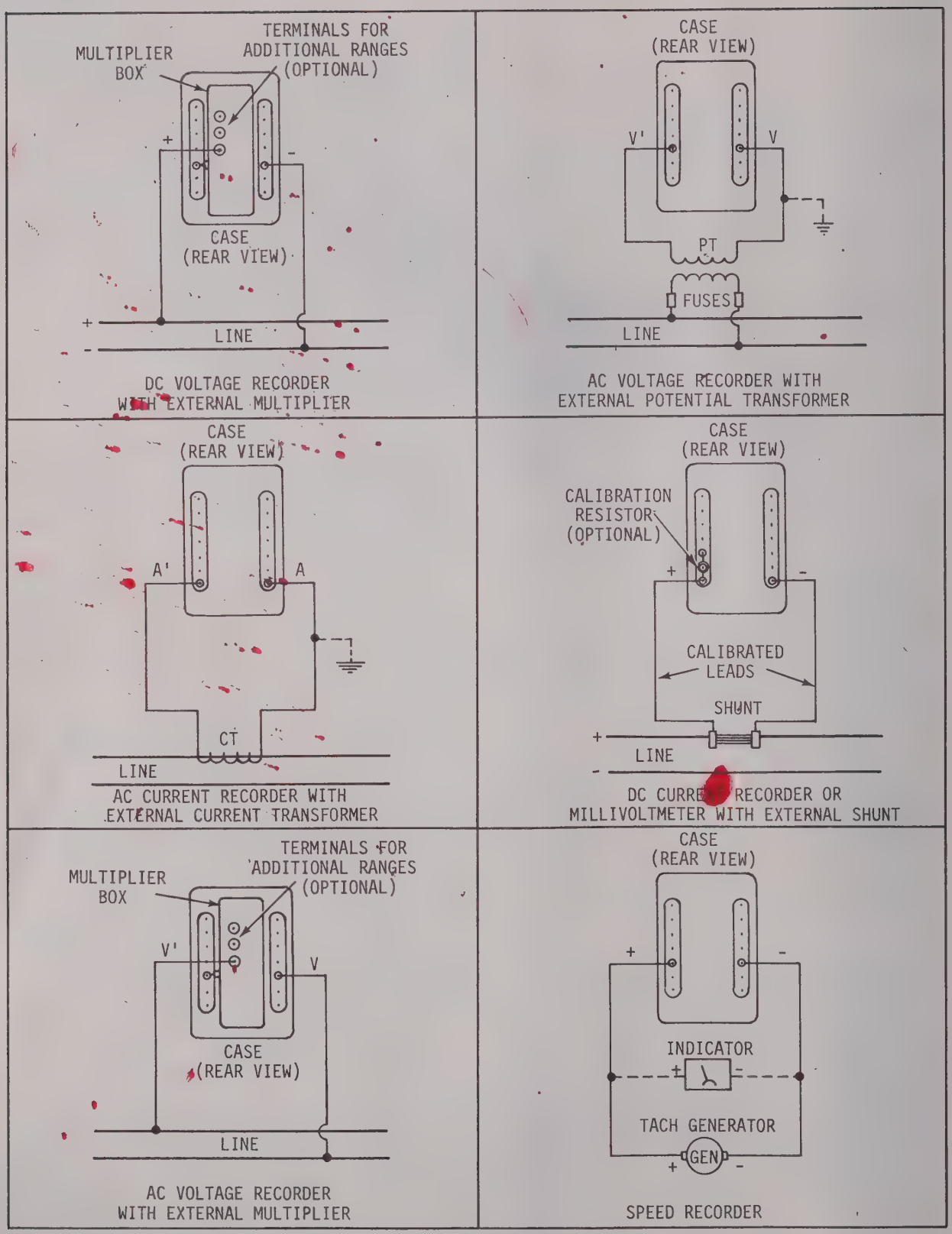


Figure C3. Standard External Connection Diagrams for Analog Inputs.

2.3.2 Inking Procedures

a. Open the case door or remove the front cover. Turn off the chart drive and de-energize the measuring system. Swing the scale-plate upward, grasp the front lip of the plastic inkwell, and lift the well up and out of the instrument.

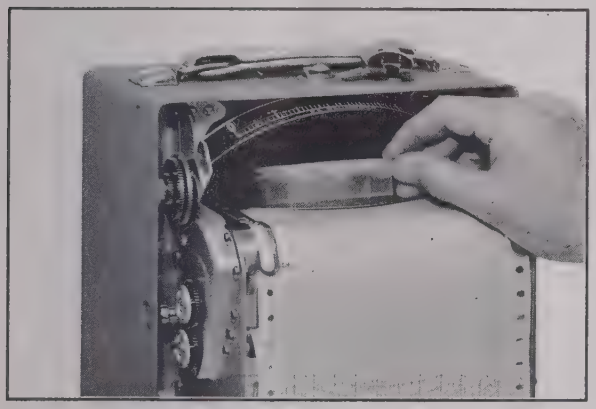


Figure C4. Removing the Inkwell.

b. Fill the inkwell slightly over half full of Esterline Angus ink using the special filler syringe supplied. Carefully replace the inkwell under the spring holder in the instrument.

CAUTION: Keep the ink bottle tightly capped when not in use.

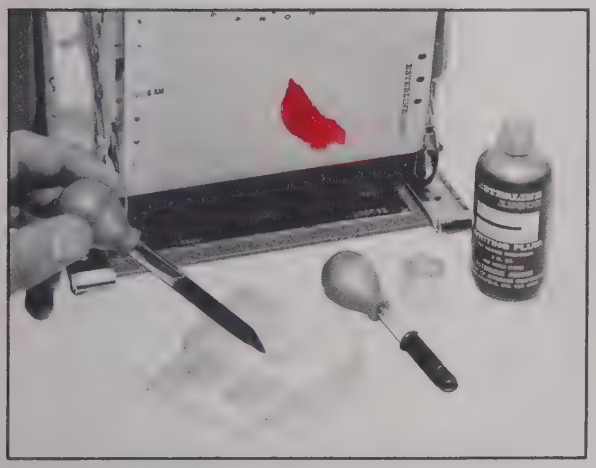


Figure C5. Filling the Inkwell.

c. Carefully seat knife-edge pivot of the pen element firmly between the movement fork assembly while guiding the lower tube into the inkwell. The pen will usually remain off of the chart until filled with ink.

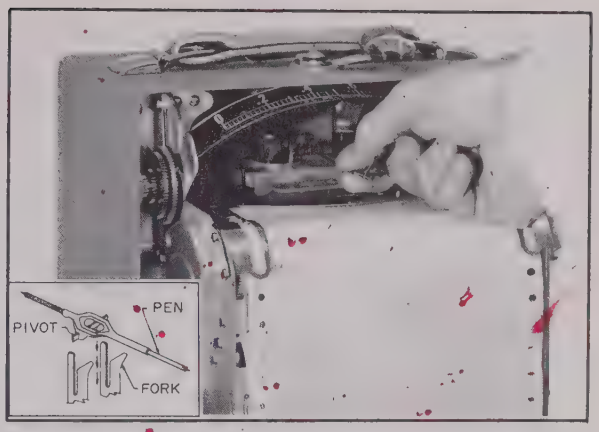


Figure C6. Installing the Pen.

d. To prime the system, compress the pen-filler bulb, insert the pen point into the small hole provided in the rubber tip of the filler, and release the bulb slowly until ink appears in the glass tube of the filler. When priming, avoid extracting an excessive quantity of ink from the inkwell.

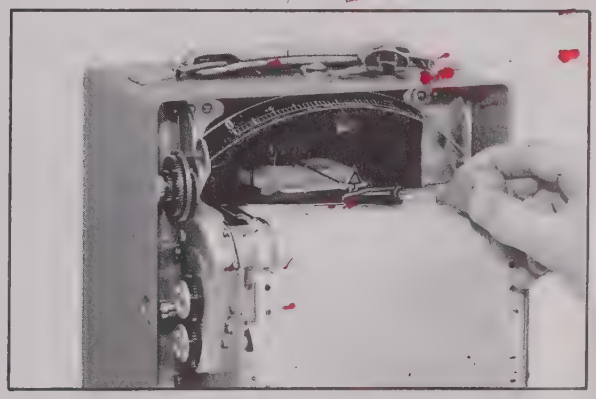


Figure C7. Priming the Pen.

e. After priming the pen, return the scale-plate to its normal viewing position. Make sure that the pen point is at a right angle to the chart, and check for proper inking. The recording system is now ready for operation.

CAUTION: Always remove the pen and inkwell before subjecting the instrument to handling that may spill ink. If ink is spilled on the recorder, remove immediately with a damp cloth or paper towel.

f. Wash the accessory syringes with clear water after each use. If ink is spilled on clothing, the spots should be washed as soon as possible, preferably with warm water and Lava soap. Persistent washing will usually remove such spots. Refer to the maintenance

instructions in this part of the manual for additional care of the inking system.

NOTE: To insure a continuous record and eliminate repriming procedures, always keep the system supplied with ink.

2.4 ADJUSTMENTS

Esterline Angus recorders are carefully adjusted and properly tested before leaving the factory; however, the following field adjustments may be required to satisfy various applications.

NOTE: Refer to the appendix (PART D) for additional adjustment procedures when optional transducers or signal-conditioning amplifiers are supplied.

2.4.1 Pen Balance

a. Adjustable weights are provided on the rear of the pen shaft for the purpose of balancing the element. When a pen element is placed into operation for the first time, it will not rest on the chart until completely filled with ink. The pen supplied with a recorder has been properly balanced so that when filled with ink it will record on the chart paper with a minimum of point pressure.

b. Excessive pen pressure may cause recorder response to appear sluggish, while insufficient pen pressure may cause skips in the recorded trace. If, for any reason, it becomes necessary to adjust pen balance, refer to the procedures given in the maintenance instructions.

NOTE: Skips in the recorded trace may be normal when sudden full-scale deflections are encountered.

2.4.2 Zero Adjust

a. Zero setting of the pen element must be checked periodically to insure accurate recording. Before attempting this adjustment, however, make certain that no signal is applied to the input terminals and that the pen is full of ink and is correctly balanced. To zero the analog pen, proceed as follows:

CAUTION: If a correct zero setting cannot be obtained, refer to the trouble-shooting procedures in the maintenance instructions. DO NOT BEND PEN STAFF.

b. Open case door or remove cover. Locate the zero adjust lever on the inside floor of the case. Shift the lever laterally and tap lightly on the chart paper near the pen until the pen point comes to rest exactly on the zero reference line of the chart span.

NOTE: Recording errors may be introduced if zero is shifted to a position other than that for which the instrument is designed.

SECTION 3 — MAINTENANCE

3.1 GENERAL

a. The components employed in the measuring system of this recorder are designed and rated for long, trouble-free operation. Nevertheless, they should receive the care afforded any precision piece of equipment to extend their useful life.

b. Should adjustment or minor service become necessary in the field, refer to the maintenance procedures that follow. Refer to PART B of this manual for chart drive maintenance procedures, and to the appendix (PART D) for special instructions on optional systems. In the few cases where major repairs are necessary, contact your local Esterline Angus representative for instructions.

3.2 ROUTINE MAINTENANCE

Except for replacing chart paper and adding ink to the inkwell, the recorder should require little attention. Periodic maintenance schedules should, however, be established which include inspection, cleaning, and adjustment of the measuring and recording system.

> WARNING: To prevent accidental shock, always remove power from the instrument before disassembling or servicing.

3.2.1 Inspection

a. A visual inspection of the measuring system and inking components should be made at each maintenance period with particular attention to the following:

(1) Ink and chart supplies.
(2) Accumulation of dirt or other foreign material within the instrument.
(3) Leaky or clogged inking system.
(4) Worn or bent pen element.
(5) Check zero and pen balance adjustments.
(6) Look for damaged wiring, loose connections, or burnt electrical components.

b. If any of the above items are evident, corrective measures should be taken without delay.

3.2.2 Cleaning

a. The recorder case and external surfaces of certain measuring system components (such as terminal blocks and scaleplate) may be cleaned with a dampened cloth and wiped dry with a lint-free cloth.

> NOTE: See "Care of Inking System" for pen and inkwell cleaning procedures.

b. The chart drive should be removed from the instrument case to gain access to the internal measuring-system components. A low-pressure vacuum or non-metallic, soft-bristled brush may be used to clean all electrical parts.

> CAUTION: Do not disturb parts or routing of wiring during cleaning procedures.

3.2.3 Care of Inking System

a. To achieve proper inking, the ink supply and pen element must be inspected regularly. Fresh ink should be added whenever needed, and the pen point kept free from dirt, lint, and dried ink at all times. Once a month the inking components should be emptied, washed, and refilled with fresh ink. Also clean all inking tools after each use.

b. Intermittent writing or a tendency of the ink to spread on the chart paper are often indications that the system should be cleaned. Intervals for cleaning will depend upon environmental conditions and the nature of instrument operation.

c. If records are obtained with large and frequent excursions of the pen, or at relatively fast chart speeds, ink will flow rapidly and there will be little chance of the system clogging. If the system has long idle periods, on the other hand, it may be necessary to clean the system after each use.

d. The pen may be cleaned by drawing ink through the system. Position the rubber tip of the primer syringe over the pen point and prime the system until several drops of ink come from the pen point; blot the tip and check operation. This routine procedure should remove any paper fiber or dirt that has accumulated in the pen point.

e. If this procedure fails to restore satisfactory inking, remove the pen element from the instrument. Fill the flusher syringe with clear water and backflush the pen element. If pen tip remains clogged, insert cleaning wire in pen point and carefully work wire straight in and out of pen; then repeat flushing procedures. Do not use cleaning wire unless absolutely necessary. Keep it centered in pen and avoid scraping sides of orifice. If the tip has become permanently damaged, it will be necessary to replace the pen tip or the entire element.

3.3 PEN BALANCE ADJUST

The small nut-like weights on the rear of the pen element may be repositioned to obtain proper pen balance. If pen-point pressure is too great, move the nuts backward; if too little, move the nuts forward.

3.3.1 Adjustment procedures

a. To change pen balance proceed with the following steps:

(1) Open front of recorder case, see that a chart is installed, and that the pen element is full of ink.

(2) Turn on the chart drive, energize the measuring system, and tilt the scaleplate upward.

(3) Observe recording characteristics and determine which direction the nuts should be moved if the pen is out of balance.

(4) De-energize the measuring system and carefully remove the pen element from the movement fork assembly.

CAUTION: Avoid spilling ink by turning the pen upsidedown.

(5) Loosen the back nut on the pen shaft, turn the front nut forward or backward as deemed necessary for proper balance, and then screw the nuts together finger tight.

NOTE: Nuts will only remain in position if screwed tightly against each other.

(6) After positioning the nuts, place pen element back in the recorder and check operation. Repeat the above procedures until the desired balance is obtained.

b. Pen balance should be such that the pen point slightly bounces up from the chart when the chart paper adjacent to the pen is sharply tapped with the forefinger. If maximum response speed is desired, pen-point pressure must be no greater than necessary to produce a satisfactory ink trace.

3.4 CALIBRATION

a. The accuracy of a recorder may be questioned because its readings do not agree with those of indicating instruments in the same circuit. In such a case, make sure that the indicators themselves are properly connected and are accurately calibrated. It is frequently found that indicating instruments are in error due to incorrect connections or because they have suffered physical or electrical damage. Often, this is not discovered until a recorder is connected into the same circuit and a direct comparison made.

b. Before making any calibration check of the instrument, the following points should be noted:

(1) Check pen element length; it should be 4 3/8" from knife edge to writing tip. A 1/16" variation in pen length will produce a full-scale error of approximately 1.5%.

NOTE: If length is incorrect, see that writing tip is inserted into the element tube to the proper depth.

(2) Make sure that the pen element is seated properly in its fork and that it swings freely. It should not stick at any point across the entire chart span. If it rubs on the scaleplate or inkwell, carefully straighten the element for clearance.

(3) With input disconnected, see that the pen is properly balanced and is set correctly on zero.

(4) Carefully measure the width of the ruled portion on the chart; it should be exactly 4.50 inches. Extreme humidity and/or temperature conditions may cause the paper to expand or contract.

NOTE: Use only Esterline Angus precision charts for guaranteed accuracy.

(5) Make sure that the instrument is not sharply tilted. It must not be positioned close to metallic objects or near the source of a strong magnetic field.

3.4.1 Calibration Procedure

a. Instrument calibration should be checked against a known-accurate standard. Disconnect the external analog input leads from the recorder and connect the calibration signal source to the correct input terminals.

CAUTION: Always observe polarity markings and see that all connections are clean and tight.

b. When checking calibration, the ambient temperature should be as close as possible to the factory calibrating temperature of 25 degrees Centigrade. This is particularly important for DC systems using external current shunts. A warmup time may also be required for measuring systems employing an internal amplifier.

NOTE: Special measuring systems may require separate calibration adjustments. Refer to the appendix (PART D).

c. Always read the measured value by the position of the pen on the chart ruling and not by the pointer and scaleplate. The indicating scale does not provide the degree of accuracy required for calibration.

d. If recording errors exceed the accuracy limits specified for the overall system, follow the service procedures given under "TROUBLESHOOTING." If difficulties persist, return the instrument to the factory for repair and recalibration (consult your local Esterline Angus representative for shipping instructions).

3.5 DISASSEMBLY

a. The measuring system (including galvanometric movement and its circuit components)

may be removed from the recorder case as a complete module.

WARNING: Remove power from the instrument before disassembling or servicing.

b. The measuring system is removed from a standard recorder as follows:

NOTE: On switchboard or wall-mounted instruments it may be necessary to remove them from the panel or wall for access to the rear of the case.

(1) Open front of recorder case, turn off power, and carefully remove pen element and inkwell.

(2) Remove the chart drive by following procedures given in PART B of this manual.

(3) Free the zero adjust lever from the floor of the case by removing the hold-down bar.

(4) Remove all external lead connections and remove four screws securing terminal blocks to the rear of the case.

(5) Remove three screws securing movement mounting plate to the center-rear of the case.

(6) Being careful not to damage the zero-adjustment mechanism, lift the assembly up and out from the front of the case.

CAUTION: Do not rest assembly on zero adjustment rod, and never remove the armature from the magnet structure unless means are available to recharge the magnet-armature assembly and recalibrate the instrument.

3.6 PEN TIP REPLACEMENT

a. The replaceable metal pen point for pen element #8510 should be a push fit into the end of the pen tube. Therefore, extra pen points have a sizing wire furnished with them for use when the new point fits loosely into the pen element tube. To use this wire, insert it into the pen element tube and squeeze the tube about 1/16 inch from its end with narrow flat-nosed pliers. Remove the sizing wire and insert the tip of the long end of the pen point into the tube.

b. Place a drop of lacquer or nail polish on the body of the pen point and then push and twist it into the tube until the distance from the knife-edge pivot to the writing point is 4 3/8". The lacquer or nail polish will seal the point into the tube. The point should be positioned so that it rests perpendicular to the chart when the pen element is installed in the recorder.

3.7 TROUBLESHOOTING

a. The simplified troubleshooting guide presented in Table C8 may be used to correct minor measuring-system troubles that occur in the field. The guide describes the most common troubles, lists the most frequent causes, and suggests the most likely remedy procedures. Refer to Part B of this manual for troubleshooting instructions dealing with the chart drive system of the recorder.

b. If trouble is indicated in the electrical measuring system, the most logical troubleshooting approach is to isolate the fault to one electrical module or component--such as a transformer, rectifier network, internal amplifier, or movement armature. Voltage and current measurements, continuity checks, and DC resistance measurements may be necessary to pin-point the trouble. Refer to the appropriate schematic in Figure C8.

CAUTION: Always remove power from instrument before making DC continuity checks or resistance measurements.

c. If trouble is traced to a defective internal amplifier, refer to the supplemental instructions in the appendix of this manual and to the measuring circuit schematics of Fig. C8. Check the power supply and signal circuits of the amplifier using conventional troubleshooting techniques.

d. If trouble is traced to a defective movement, measure circuit resistance; also examine leads and springs while carefully turning the armature. If internal armature leads have been burned off or the control springs physically damaged, return the instrument to the factory for service.

CAUTION: Do not remove armature from magnet structure unless means are available to recharge the magnet-armature assembly and recalibrate the instrument.

e. If any measured values differ from those shown on one of the circuit schematics or on the Data Sheet, locate and replace the faulty component. If adequate repair facilities are not available, contact the nearest Esterline Angus field representative for instructions.

3.8 REPLACEMENT PARTS

All measuring and recording system parts are made available directly from Esterline Angus. When ordering parts, always give descriptions, part numbers and instrument serial number. Refer to PART A for case parts and to the illustrations in this manual for other parts identification.

TABLE C8

MEASURING SYSTEM TROUBLESHOOTING GUIDE

TROUBLE SYMPTOM	PROBABLE CAUSE	SUGGESTED REMEDY
System inoperative. (no deflection)	Source failure or faulty connection.	Check input signal and all connections (refer to para. 2.2.2).
	Open or defective measuring circuit.	Test and replace faulty component(s) (refer to para. 3.7b & c).
	Defective movement.	Check movement armature assembly (refer to para. 3.7d).
All recorded values in error.	Zero misadjusted.	Adjust zero (refer to para. 2.4.2).
	Faulty recording system.	Check adjustments, pen element and chart (refer to para. 3.4b).
	Defective measuring system.	Test for faulty component (refer to para. 3.7b, c & d).
System is insensitive or sluggish.	External circuit resistance too low.	Check signal source resistance and recorder specifications (refer to para. 1.3).
	Incorrect pen balance.	Reduce pen-point pressure (refer to para. 3.3).
	Defective measuring system.	Test for faulty component (refer to para. 3.7b, c & d).
Erratic pen deflection.	Intermittent connection.	Check all external and internal connections.
	External interference.	Check signal source and environmental conditions.
	Defective measuring circuit.	Test for faulty component (refer to para. 3.7b, c & d).
Pen oscillates. (System with internal amplifier).	Loss of source impedance.	Look for open input circuit.
	Signal interference.	Check for AC component.
System will not zero.	Mechanical part binding, loose, or broken.	Check zero adjustment mechanism and refer to para. 3.4b step (2).
	Defective movement.	Check movement armature assembly (refer to para. 3.7d).
Inking system inoperative.	Loss of prime or clogged pen.	Reprime or clean system (refer to para. 3.2.3d & e).
Inking pen skips.	Incorrect pen balance.	Increase pen-point pressure (refer to para. 3.3).
	Restricted ink flow.	Clean pen element (refer to para. 3.2.3d).
	Pen element improperly installed.	Check pen element alignment [refer to para. 3.4 steps (1) and (2)].
Ink trace spreads on chart paper.	Inferior ink or chart.	Use only recommended EA supplies.
	Dirty pen point or contaminated ink.	Clean inking system (refer to para. 3.2.3).

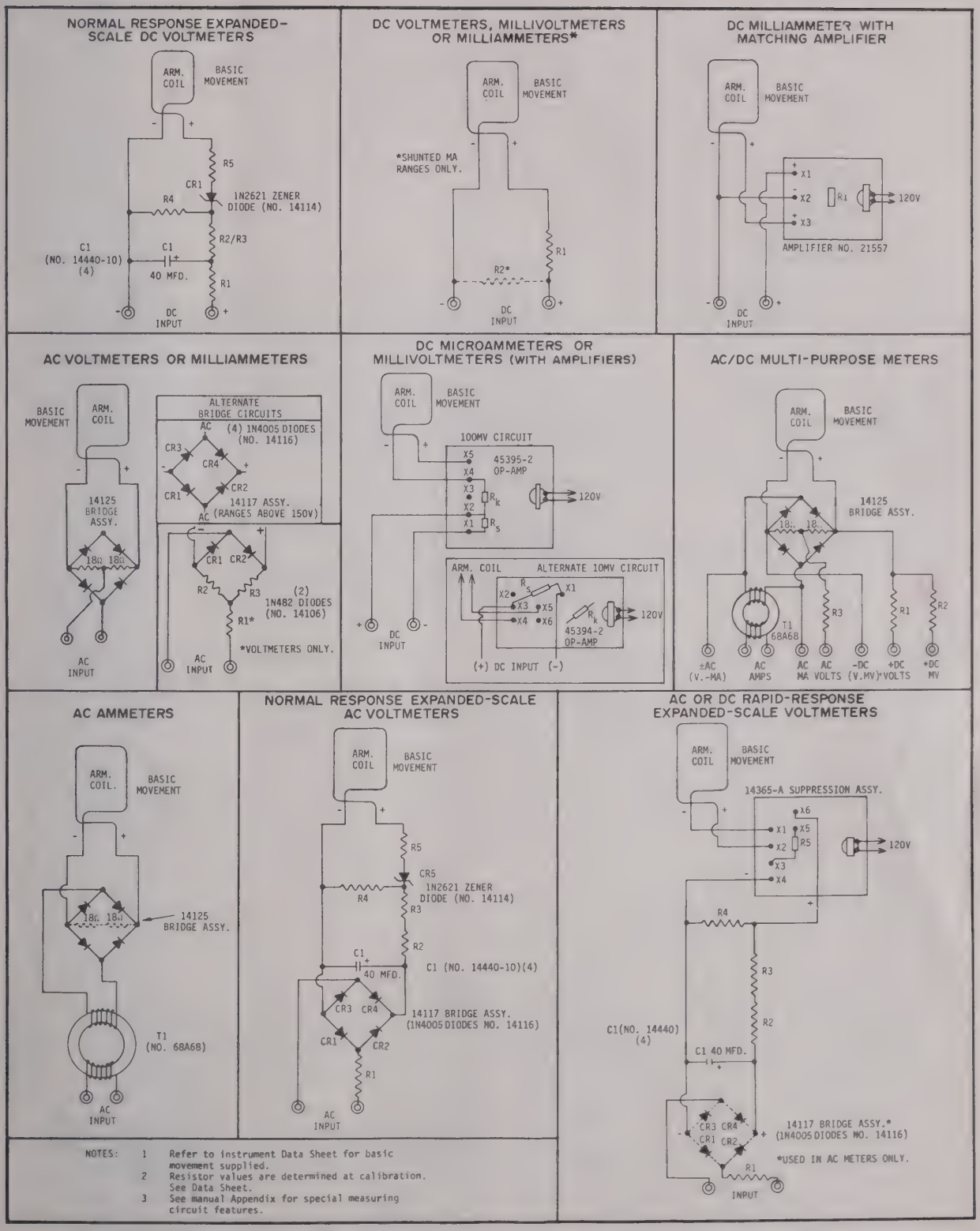


Figure C8. Measuring Circuit Schematic Diagrams.

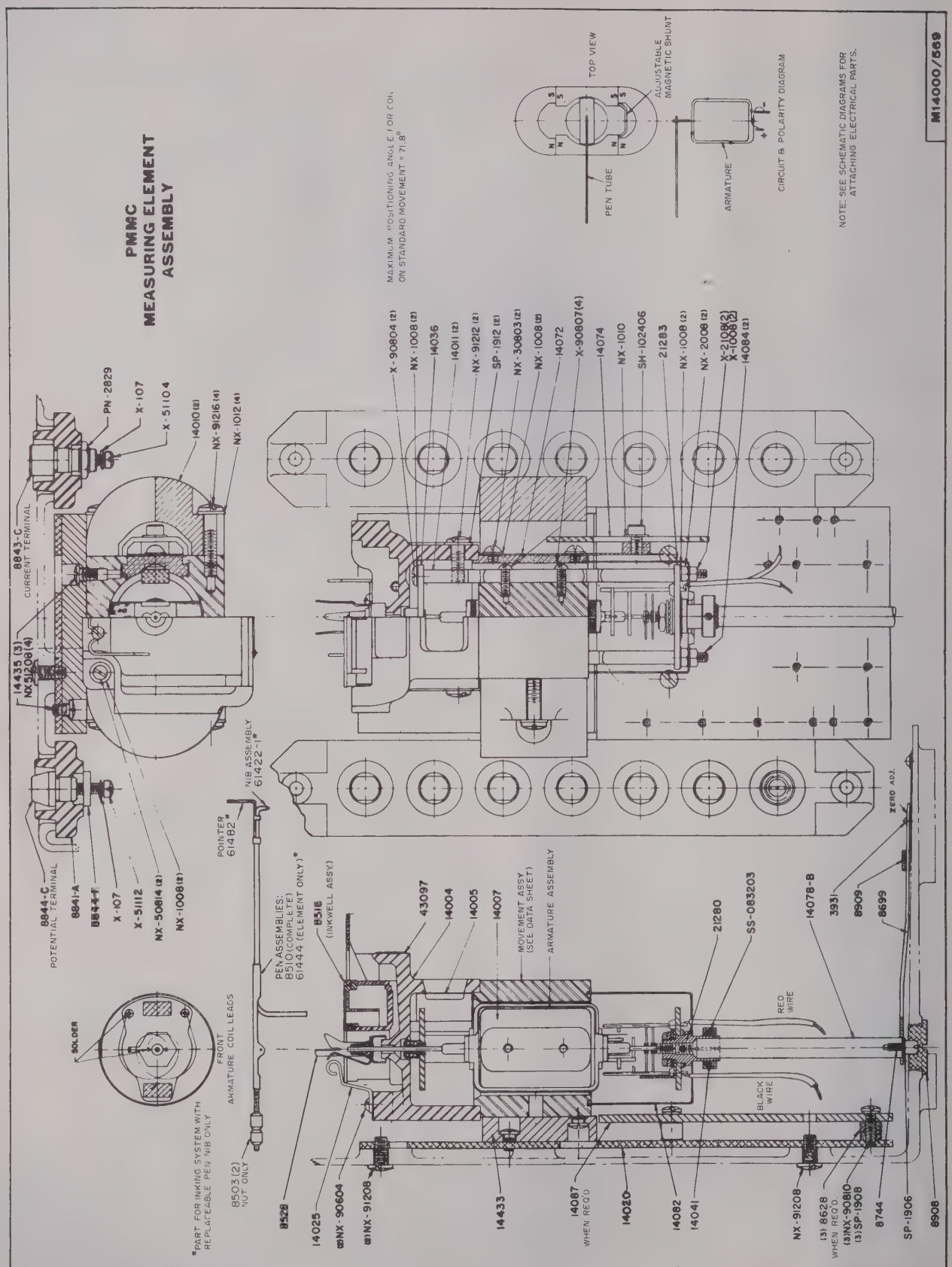


Figure C9. Movement Assembly Parts Location Diagram.

PART D

APPENDIX

SECTION 1 — OPTIONAL ACCESSORIES

1.1 EVENT PENS

1.1.1 General

a. Event "pens" are attachments designed to record "on-off" indications on the margins, outside the ruled portion of the chart paper, while the analog record is made on the chart. The time and duration of the occurrence is recorded in relation to the analog recording. One or two event pens can be mounted on the recorder and are identified as the Right Hand (R. H.) or Left Hand (L. H.) pen.

b. An event pen is actuated by an electromagnet assembly. When voltage (the signal to be recorded) is applied to the coil of the electromagnet, the pen moves toward the edge of the chart paper. When voltage is removed, the pen returns to the normal "off" position.

c. The event pen assembly is mounted at the top right or left of the analog recorder movement. The leads of the magnet coil are connected to the input terminals on the rear of the case. Terminal connections and electrical ratings are specified on the instrument Data Sheet.

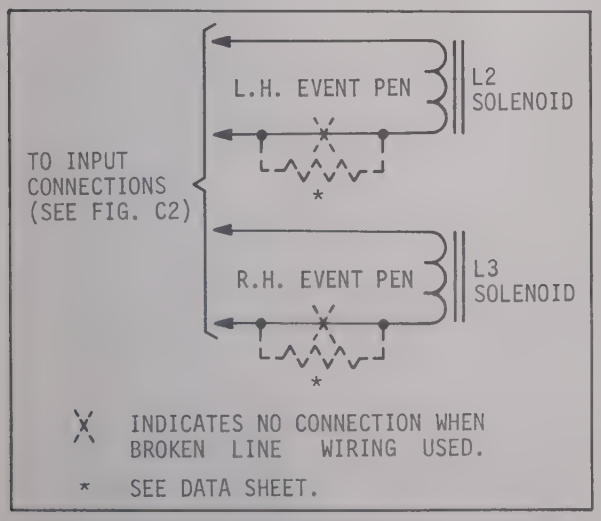

L.H. EVENT PEN
L2 SOLENOID
TO INPUT CONNECTIONS (SEE FIG. C2)
R.H. EVENT PEN
L3 SOLENOID
INDICATES NO CONNECTION WHEN BROKEN LINE WIRING USED.
* SEE DATA SHEET.

Figure D1. Event Pen Connections.

1.1.2 Inking System

a. To fill the event-pen inkwell, remove the pen-inkwell assembly and unscrew the knurled inkwell cover. Fill the inkwell to within 1/4" of the top with E-A graphic ink (about 20 drops), with the filler syringe. Replace the inkwell cover.

b. To prime the pen, compress the pen-filler bulb and insert the pen point into the hole provided in the tip of the filler. Release the bulb pressure slowly until ink appears in the glass tube of the filler. Do not withdraw excessive ink from the inkwell.

c. Replace the pen-inkwell assembly in the bracket. Be sure the tail of the assembly engages the lever arm on the electromagnet.

1.1.3 Pen Adjustment

a. The event pen recording is snychronized with the analog recording when the tip of the event pen rests on the chart directly in line with the tip of the analog pen (at the point of fullest swing towards the event pen). The event pen should record, with a stroke of approximately 1/16", on that portion of the chart paper between the side paper guide and the edge of the analog ruling. If necessary, the event pen may be aligned as follows:

(1) Place analog and event pens in operating position on chart. Position chart so analog pen tip is resting on horizontal time line of chart at full swing towards event pen.

(2) Loosen adjustment screws on pen assembly side mounting bracket.

(3) Adjust event pen until tip rests on same horizontal time line of chart with analogue pen.

(4) Hold event pen in position and tighten bracket screws.

NOTE: Additional lateral adjustments are provided. Loosen mounting screws below pen coil and adjust as required.

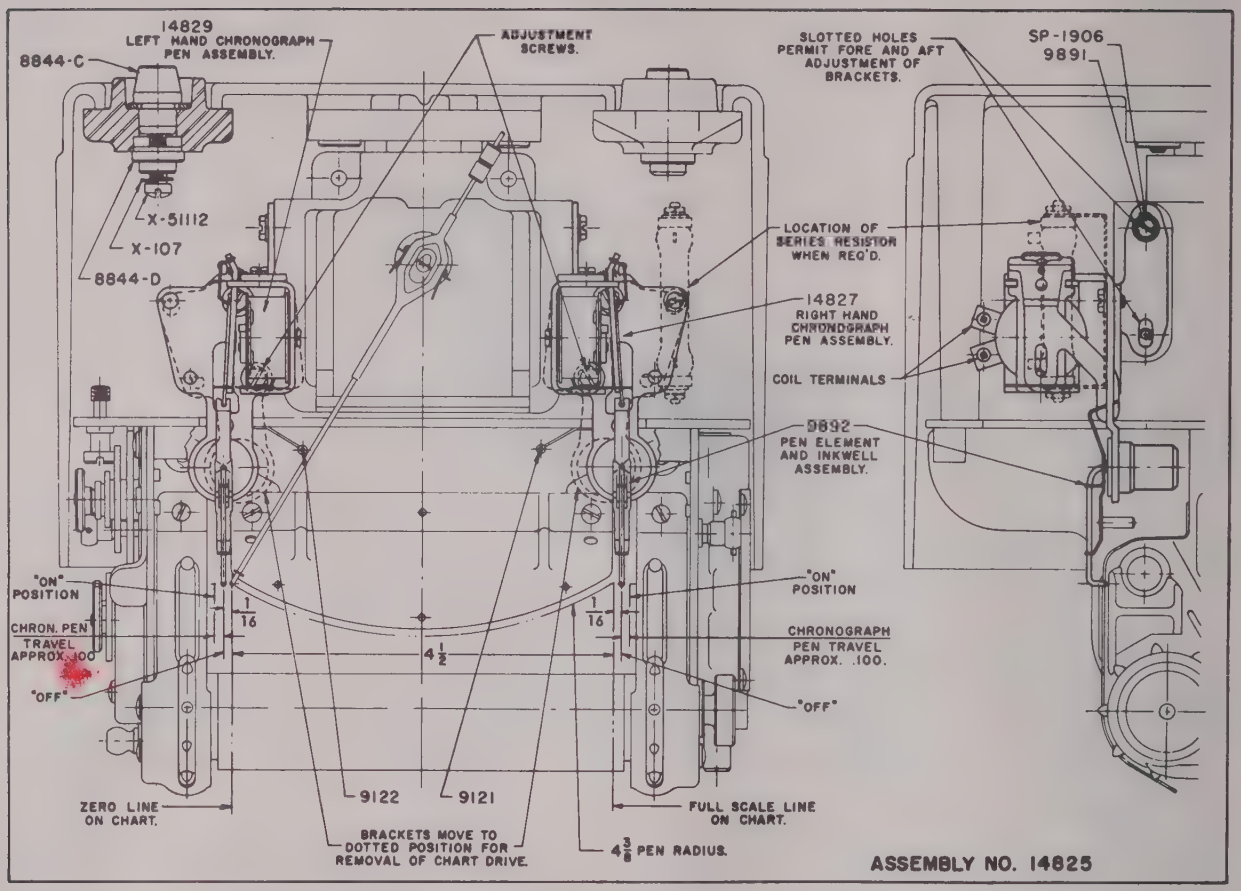


Figure D2. Event Pen Parts Location.

1.1.4 Replacement Parts

To order parts, see Figure D2. Always specify electrical ratings and whether pen is right-or left-hand unit.

1.2 ALARM CIRCUIT

a. Esterline Angus alarms are fundamentally voltage-sensing relays that may be automatically controlled by the measured analog signal of the recorder. Alarms are housed in a multiplier box either attached to the recorder case or as a separate unit. One or two alarms may be operated from a single input source; and, since the alarm circuits are completely electronic, no mechanical connections to the signal source or measuring system are required. The heavy-duty relay incorporated in each alarm circuit provides two output contacts--one normally open and one normally closed. These contacts may be used to control the "ON" or "OFF" condition of any external circuit within ratings of the relay.

b. Basically, the alarm system compares the DC input signal with a preselected reference potential, and the resulting differential triggers a transistorized switching circuit. This signal is then amplified and immediately actuates a single-pole double-throw relay. Each relay and each amplifier is packaged in a dust-tight, plug-in module for easy field replacement. Each alarm circuit also features a "set-point" potentiometer; thus permitting the operator to program or manually select the precise input signal level that will trigger the output relay.

c. The function module in each alarm circuit determines input sensitivity. All components of this input circuit are mounted on a single terminal strip that features spade-type connectors, therefore making it convenient to replace or interchange modules using only a screwdriver.

d. Refer to the data sheet and connection diagram (Fig. D3) before making any electrical connections to the alarm circuit. If the alarm is to be operated with other than Esterline Angus equipment, connections will be recommended upon request.

e. To set the operating point of an alarm circuit, energize the power supply, apply a DC signal of the desired actuation level, and carefully adjust the "set-point" potentiometer until the alarm relay actuates. A slight click should be heard confirming actuation. If the click is not easily detected, a test lamp or ohmmeter may be placed across the relay terminals while performing this adjustment.

NOTE: The transistorized alarm circuits have relatively low input impedance without bias voltage; therefore, always see that the alarm power supply is energized or remove the plug-in module to avoid excessive loading.

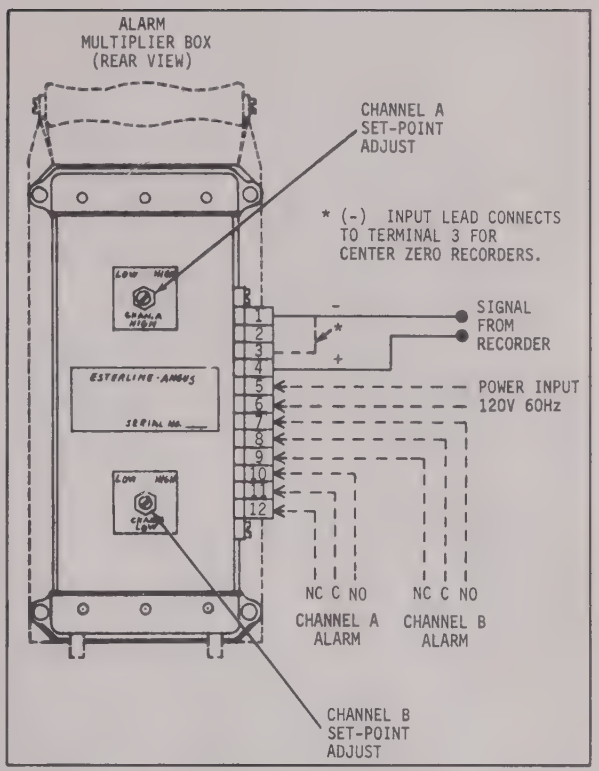


Figure D3. Alarm Circuit Connection Diagram.

TABLE D1

ALARM CIRCUIT SPECIFICATIONS

Function Modules
Voltage Sensing----------2, 5 and 10 Volts DC. (Extended with voltage dividers)

Input Impedance
Actuated----------60K Ohms (Minimum per circuit)

Accuracy Characteristics

Input Ranges	Repeatability (Pull-in or drop-out actuation point)	Hysteresis (Deadband between pull-in & drop-out)
2-Volt	±1.0% FS	2.0% FS
5-Volt	±1.0% FS	1.0% FS
10-Volt	±1.0% FS	0.5% FS

Set-Point Potentiometer----------Adjustable over entire range

Output Relay
Type (Plug-In)----------Single Pole, Double Throw
Rating (@120V AC)----------5A Non-inductive

Ambient Temperature Range----------+20° to +120°F

Power Requirements----------120V ±10%, 50-60 Hz

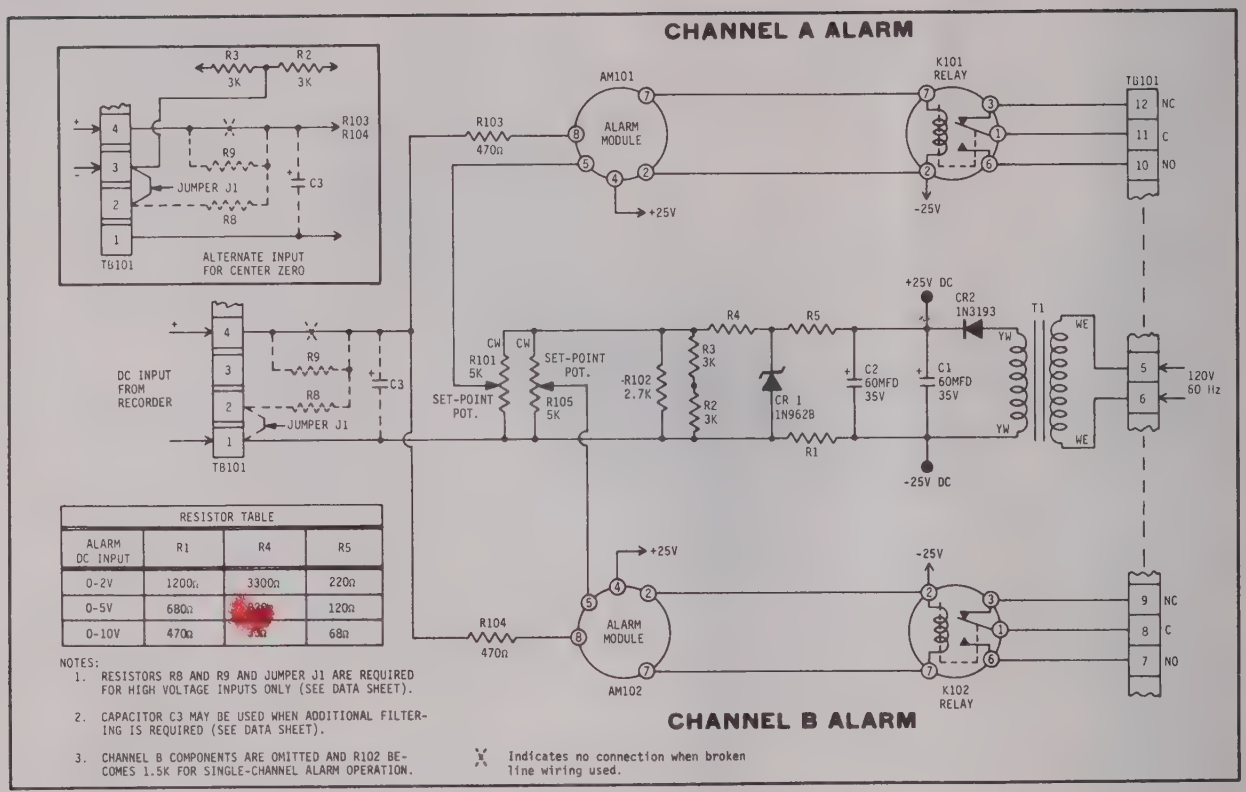


Figure D4. Alarm Circuit Wiring Diagram.

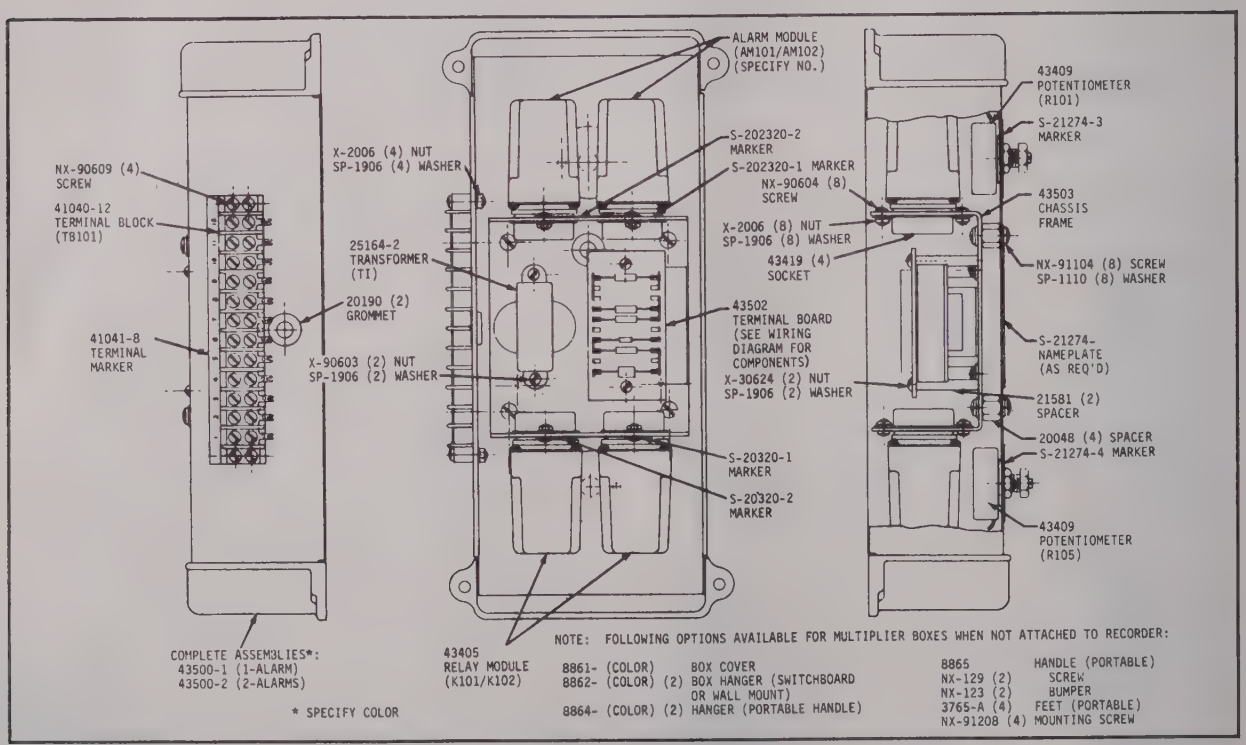

NX-90609 (4) SCREW
41040-12 TERMINAL BLOCK (TB101)
41041-8 TERMINAL MARKER
X-2006 (4) NUT SP-1906 (4) WASHER
25164-2 TRANSFORMER (T1)
20190 (2) GROMMET
X-90603 (2) NUT SP-1906 (2) WASHER
ALARM MODULE (AM101/AM102) (SPECIFY NO.)
S-202320-2 MARKER
S-202320-1 MARKER
NX-90604 (8) SCREW
X-2006 (8) NUT SP-1906 (8) WASHER
43419 (4) SOCKET
43502 TERMINAL BOARD (SEE WIRING DIAGRAM FOR COMPONENTS)
X-30624 (2) NUT SP-1906 (2) WASHER
S-20320-1 MARKER
S-20320-2 MARKER
43409 POTENTIOMETER (R101)
S-21274-3 MARKER
43503 CHASSIS FRAME
NX-91104 (8) SCREW SP-1110 (8) WASHER
S-21274- NAMEPLATE (AS REQ'D)
21581 (2) SPACER
20048 (4) SPACER
S-21274-4 MARKER
43409 POTENTIOMETER (R105)
COMPLETE ASSEMBLIES*: 43500-1 (1-ALARM) 43500-2 (2-ALARMS)
* SPECIFY COLOR
43405 RELAY MODULE (K101/K102)
NOTE: FOLLOWING OPTIONS AVAILABLE FOR MULTIPLIER BOXES WHEN NOT ATTACHED TO RECORDER:
8861- (COLOR) BOX COVER
8862- (COLOR) (2) BOX HANGER (SWITCHBOARD OR WALL MOUNT)
8864- (COLOR) (2) HANGER (PORTABLE HANDLE)
8865 HANDLE (PORTABLE)
NX-129 (2) SCREW
NX-123 (2) BUMPER
3765-A (4) FEET (PORTABLE)
NX-91208 (4) MOUNTING SCREW

Figure D5. Alarm Assembly Parts Location Diagram.

SECTION 2 — MEASURING SYSTEM ATTACHMENTS

2.1 INTERNAL AMPLIFIERS

Several different amplifier assemblies are available for use with measuring systems of the Model A601C. These compact solid-state devices are housed within the recorder and may be used for either impedence matching purposes, or to extend the input sensitivity of an instrument. When an amplifier is employed, refer to the Data Sheet supplied with your recorder to determine the specific type.

2.1.1 Impedance Matching Amplifier

This transistorized attachment reduces effective input resistance of the recorder and stabilizes response time by causing the measuring element to appear critically damped regardless of external circuit conditions. The amplifier is designed for recorders with 0-1.0 MA measuring elements. Measuring circuit diagrams are given in Figure C8 of this manual. See Figure D6 for the amplifier schematic and refer to Table D2 for parts replacement information.

TABLE D2. IMPEDANCE MATCHING AMPLIFIER NO. 21557 - PARTS LIST

SYMBOL	DESCRIPTION	PART NO.
Q1	Transistor (PNP)	21586
Q2	Transistor (NPN)	21584
C1, C2	Filter Capacitor	14440-75
R1	Resistor	21566-*
R3, R4	Resistor	RCC-2-102
R5	Resistor	RCC-2-101
R6	Resistor	RCC-2-103
R7	Resistor (Optional)	*
CR1, CR2	Silicon Rect.	40801
CR3, CR4	Germanium Diode	21587
TI	Power Trans.	21564-5

*See Data Sheet.

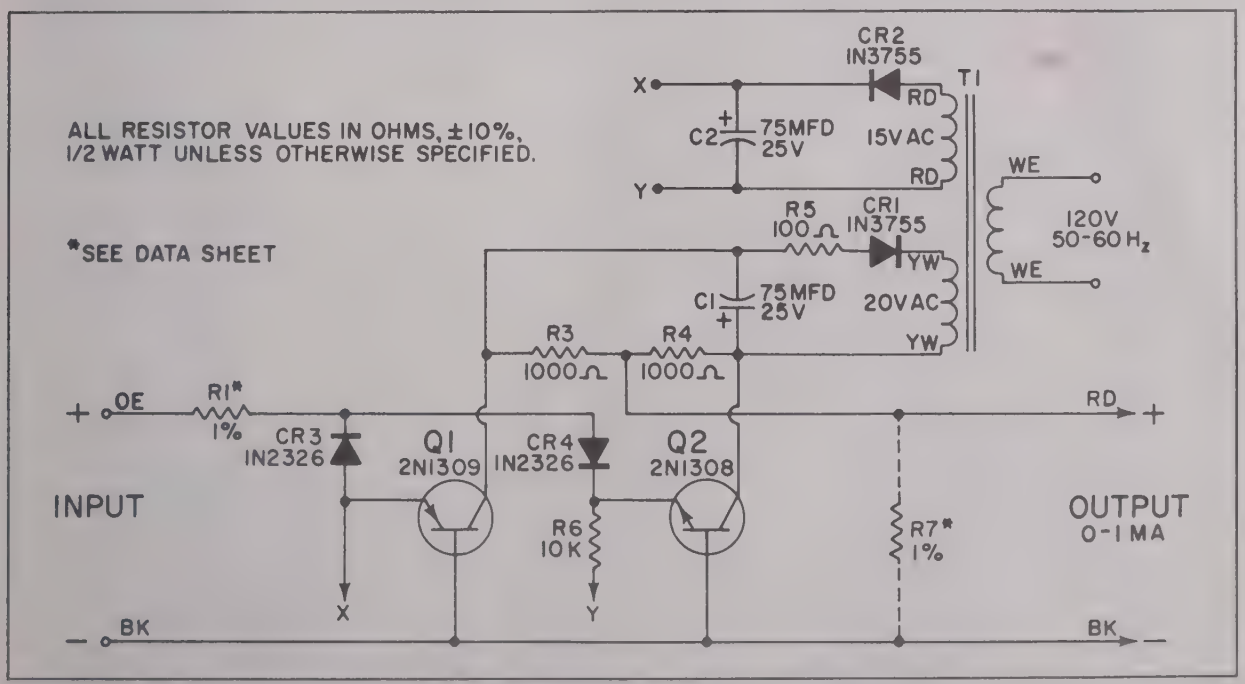


Figure D6. Amplifier No. 21557 Schematic.

2.1.2 Signal Conditioning Amplifiers

a. Internal amplifiers may be used to extend the input sensitivity of recorders by pre-conditioning their applied signals. A signal-conditioning amplifier will usually be employed in an Esterline Angus, DC millivoltmeter or microammeter recorder. Refer to the specifications in Table C4 and to the measuring circuit diagram in Figure C8. These modules are DC operational amplifiers with all solid-state components mounted on a single printed-circuit board.

b. Initial zeroing of the signal-conditioning circuit is provided by adjustment of potentiometer R12 in amplifier No. 45394, or R5 in amplifier No. 45395A. The zero control, lo-is pre-set at the factory. Readjustment should cated at the top of the printed-circuit board, only be necessary when a large change in signal-source impedance is encountered, or after certain amplifier components have been replaced in the field. When zeroing the unit, reduce the signal source to zero; but the source impedance (or equivalent) should remain connected to the input circuitry.

CAUTION: Do not use the zero adjustment to provide signal offset.

c. If long signal leads cause unwanted pick-up, a shielded, twisted pair should be used for input connections. See Figure D7 or D8 for the applicable amplifier schematic, and refer to Table D3 for parts replacement information.

NOTE: See supplemental instructions if other amplifiers are supplied.

TABLE D3. SIGNAL CONDITIONING AMPLIFIERS NO. 45394, 45395-A

45394	45395-A	REF. OR SYMBOL	PART NUMBER	DESCRIPTION
X		PC1	68B72*	PC Board Assembly (120V, 50/60Hz; Specify R_k, R_s)
X		PC1	68B72-1*	PC Board Assembly (240V, 50/60Hz; Specify R_k, R_s)
	X	PC1	45397-A	PC Board Assembly (Includes all Board-Mounted Components Except R_{k1}, R_{k2}, R_s, R_{s2}, and T1)
X	X	C1,C2	14440-100	.Capacitor, Electrolytic; 100 mfd. @25V
	X	C3	CDC-3	.Capacitor, Disc; .01 mfd. @100V
X	X	CR1,2,5,6	43421	.Diode, 1N4004
X	X	CR3,CR4	67A15	.Diode, Zener; 1N4744A
X		CR7,CR8	DIO-456A	.Diode, 1N456A
	X	IC1	57521	.Operational Amplifier (LM301A)
X		OA-1	68A78	.Operational Amplifier (Analog Devices, Inc., Model 183K)
X		R5	—	..Resistor (Part of OA-1)
X		Q1	67A13	.Transistor, 2N4921
	X	Q1	45362	.Transistor, 2N4400
X		Q2	67A14	.Transistor, 2N4918
	X	Q2	45368	.Transistor, 2N4402
X	X	R1,R2	RCC-1-330	.Resistor; 33Ω, 5%, 1/2W.
X		R3,R4	RCC-1-241	.Resistor; 240Ω, 5%, 1/2W.
	X	R3,R4	RCC-1-301	.Resistor; 300Ω, 5%, 1/2W.
	X	R5	52225-9	.Potentiometer, Zero; 25KΩ
	X	R6,R7	RCC-1-150	.Resistor; 15Ω, 5%, 1/2W.
X		R6,R8	40760-30	.Resistor; 10KΩ, 1%, 1/2W.
	X	R8	RCC-1-106	.Resistor; 10 megohms, 5%, 1/2W.
	X	R9	RCC-1-515	.Resistor; 5.1 megohms, 5%, 1/2W.
X		R9	52123-30	.Resistor; 10Ω, 1%, 1/2W.
X		R10	RMF-3-95301	.Resistor; 95.3KΩ, 1%, 1/2W.
X		R12	68A8-5	.Potentiometer, Zero; 20KΩ
X		R14,R15	RCC-1-150	.Resistor; 15Ω, 5%, 1/2W.
X		R16,R17	40760-34	.Resistor; 100Ω, 1%, 1/2W.
X		R_k	—	.Resistor, Gain (Value Determined at Final Calibration)*
X		R_s	—	.Resistor (Optional; Used for Special Input Ranges)*
X		T1	21564-1*	.Transformer, Power; 120V, 50/60Hz
X		T1	21564-6*	.Transformer, Power; 240V, 50/60Hz
	X	R_{k1},R_{k2},R_{s2}	—	Resistor (Value Determined at Final Calibration)*
	X	R_{s1}	—	Resistor (Optional; Used for Special Input Ranges)*
	X	T1	21564-1*	Transformer, Power; 120V, 50/60Hz
	X	T1	21564-6*	Transformer, Power; 240V, 50/60Hz

* Refer to Instrument DATA SHEET.

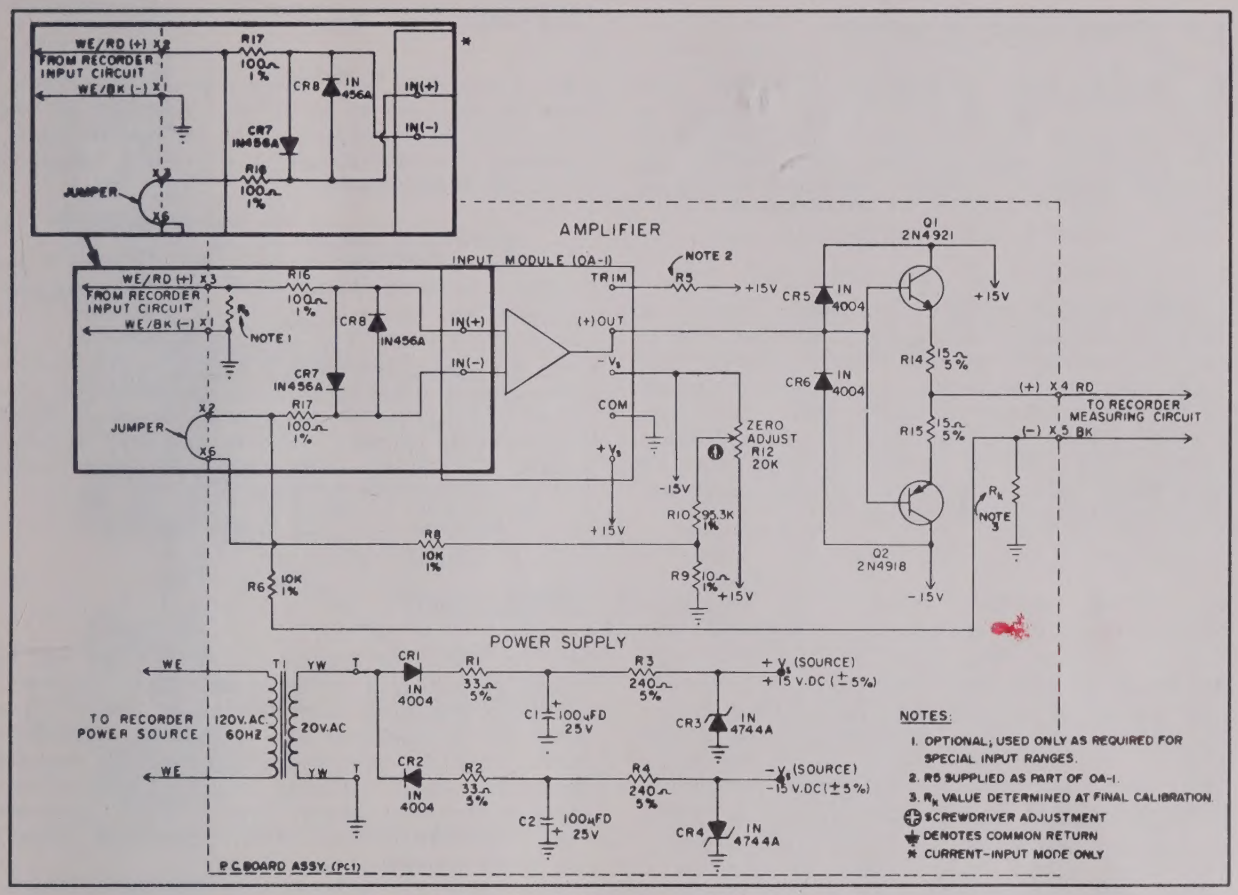


Figure D7. Amplifier No. 45394 Schematic.

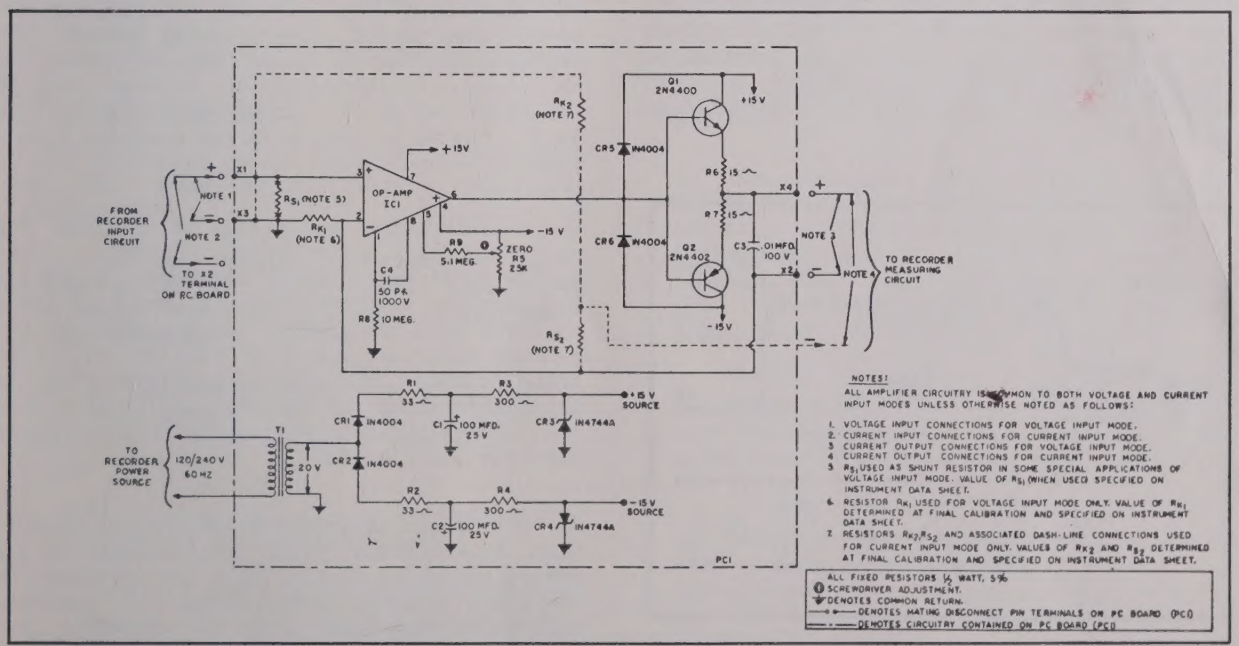

FROM RECORDER INPUT CIRCUIT
NOTE 1
NOTE 2
TO X2 TERMINAL ON PC BOARD
X1
X3
RS1 (NOTE 5)
RK1 (NOTE 6)
OP-AMP IC1
+15V
-15V
C4 50 PF 1000 V
R8 10 MEG.
R9 5.1 MEG.
ZERO R5 25K
RK2 (NOTE 7)
RS2 (NOTE 7)
Q1 2N4400
Q2 2N4402
CR5 IN4004
CR6 IN4004
R6 15
R7 15
C3 .01 MFD 100 V
X4
X2
NOTE 3
NOTE 4
TO RECORDER MEASURING CIRCUIT
TO RECORDER POWER SOURCE
120/240 V 60 HZ
T1
20 V
CR1 IN4004
CR2 IN4004
CR3 IN4744A
CR4 IN4744A
R1 33
R2 33
R3 300
R4 300
C1 100 MFD. 25 V
C2 100 MFD. 25 V
+15 V SOURCE
-15 V SOURCE
PC1
NOTES:
ALL AMPLIFIER CIRCUITRY IS COMMON TO BOTH VOLTAGE AND CURRENT INPUT MODES UNLESS OTHERWISE NOTED AS FOLLOWS:
1. VOLTAGE INPUT CONNECTIONS FOR VOLTAGE INPUT MODE.
2. CURRENT INPUT CONNECTIONS FOR CURRENT INPUT MODE.
3. CURRENT OUTPUT CONNECTIONS FOR VOLTAGE INPUT MODE.
4. CURRENT OUTPUT CONNECTIONS FOR CURRENT INPUT MODE.
5. RS1 USED AS SHUNT RESISTOR IN SOME SPECIAL APPLICATIONS OF VOLTAGE INPUT MODE. VALUE OF RS1 (WHEN USED) SPECIFIED ON INSTRUMENT DATA SHEET.
6. RESISTOR RK1 USED FOR VOLTAGE INPUT MODE ONLY. VALUE OF RK1 DETERMINED AT FINAL CALIBRATION AND SPECIFIED ON INSTRUMENT DATA SHEET.
7. RESISTORS RK2,RS2 AND ASSOCIATED DASH-LINE CONNECTIONS USED FOR CURRENT INPUT MODE ONLY. VALUES OF RK2 AND RS2 DETERMINED AT FINAL CALIBRATION AND SPECIFIED ON INSTRUMENT DATA SHEET.
ALL FIXED RESISTORS ½ WATT, 5%
SCREWDRIVER ADJUSTMENT.
DENOTES COMMON RETURN.
DENOTES MATING DISCONNECT PIN TERMINALS ON PC BOARD (PC1)
DENOTES CIRCUITRY CONTAINED ON PC BOARD (PC1)

Figure D8. Amplifier No. 45395A Schematic.

2.2 EXPANDED-SCALE VOLTMETERS

a. Expanded-scale measuring circuits are available for voltmeters in either normal- or rapid-response configurations. Specifications for these recorders are given in Table C5, and typical measuring circuits are shown in Figure C8.

b. All expanded-scale voltmeters employ a permanent-magnet moving-coil element with a modified measuring system that records the upper one fourth of the input voltage range on the upper 80% of the chart span. This expanded portion is linear and accurately calibrated. The balance of the voltage range is suppressed into the lower 20% of the span and is non-linear and uncalibrated.

c. Various voltage ranges are available through the use of calibrating resistors. Refer to the Data Sheet for the specific type and range of instrument supplied. All AC voltage recorders use a bridge rectifier and filter circuit and are calibrated in terms of RMS values for sine-wave inputs of 50 to 60 Hz. Instruments may also be calibrated for higher frequencies(such as 400 Hz)upon special order.

d. Expanded-scale voltmeters with normal-response speeds make use of a zener diode in the the suppression circuitry. All rapid-response instruments, however, include the suppression and matching network shown in Figure D9. Additional circuit components are identified in Figure C8.

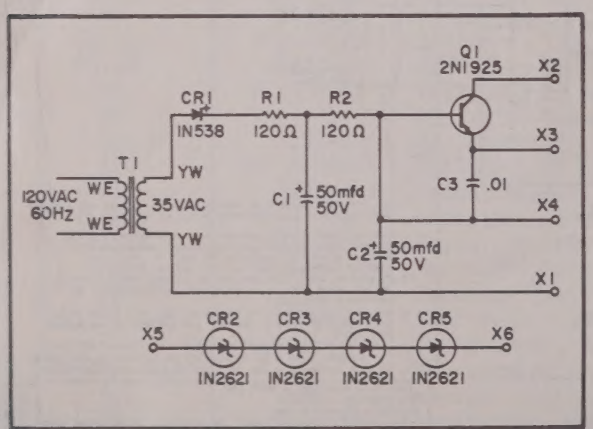


Figure D9. Schematic of Suppression Subassembly No. 14365-A.

2.3 SPLIT-CORE TRANSFORMER

a. A portable split-core current transformer may be supplied as an external attachment for use with any rectifier-type ammeter or multi-purpose recorder having an AC input range of 0-50 MA available.

b. The split-core transformer (No. 9271-A1) offers primary ranges of 50, 100 and 200 amperes and has a single 50-MA secondary. It is 6 5/8 X 6 3/4 X 3 7/8 inches overall, and has a window opening of 1 9/16 X 3 3/8 inches. The core is interleaved at the joints to provide lower reluctance and a locking pin holds it securely closed. Since the unit is metal clad, sufficient insulation must be provided to withstand line voltages.

2.4 DC SHUNTS

a. An Esterline Angus calibrated shunt may be supplied with DC ammeters or millivoltmeters. Shunts should be mounted with at least three feet of unbroken bus bar extending from both ends. Switchboard type shunts must be mounted with the blades vertical to permit free circulation of air. Never crowd a shunt into the bus structure between other shunts or install it above another shunt.

b. Special current leads are furnished for recorders used with external shunts, and are marked with the instrument serial number. Recorders with current leads are calibrated for the current measuring-circuit voltage drop AT THE SHUNT END OF THE LEADS; and only these leads should be used with the recorder specified.

c. A calibration resistance is required for all instruments using external shunts. This series resistance must be adjusted to offset the specific resistance of the extension leads employed with the shunt. When shunts and extension leads are supplied with an Esterline Angus recorder, the measuring system will be precalibrated at the factory; and in this case, no field calibration will be necessary before recorder installation.

d. When shunt extension leads are not supplied with the recorder, final calibration of the entire measuring system must be performed in the field prior to installation. A separate wire-wound resistance spool is therefore provided for convenient calibration adjustment. See Figure D10.

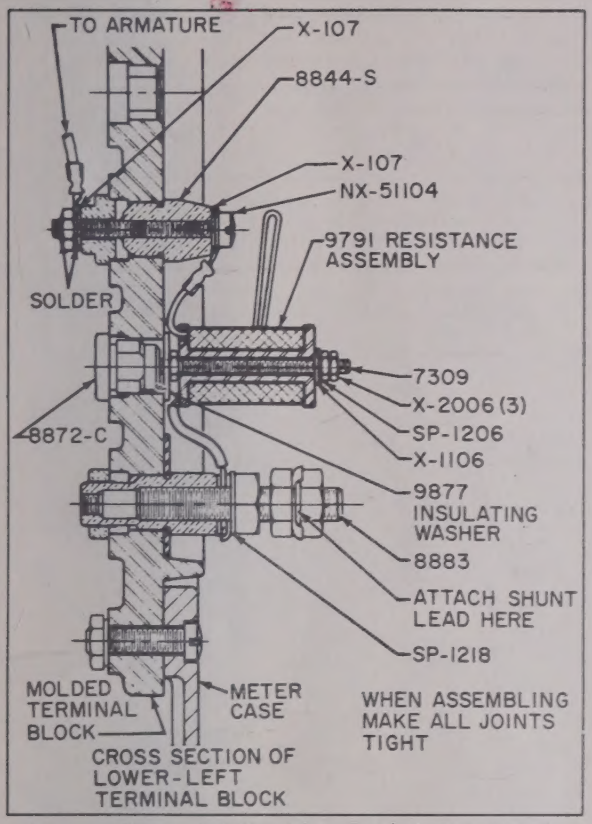


Figure D10. Calibration Resistance Spool.

2.4.1 Calibration Procedure

a. Either one of the two following methods may be used to calibrate a left-hand zero or center-zero recorder with external shunt:

b. Resistance Method:

(1) Calculate the millivolt value required at shunt terminals to produce full-scale calibration.

(2) Subtract "millivolts-of-copper" value of the measuring circuit from value found in Step 1 (See value specified on Data Sheet under "Voltage.").

(3) Divide remainder by full-scale current (see Data Sheet). This gives total Ohms required for extension leads and calibration spool.

NOTE: Divide remainder by 1/2 full-scale current for center-zero ranges.

(4) Subtract total loop resistance of leads (in Ohms at 25°C) from value found in Step 3. The remainder is the resistance required in the calibration spool.

(5) With shunt disconnected, carefully measure spool resistance and adjust by unwinding loop end of resistance wire, cutting out desired length, and soldering ends together.

NOTE: Each lineal inch of resistance wire is approximately .02 Ohm; and each loop inch approximately .04 Ohm. Total spool resistance is approximately 3 Ohms.

(6) After trimming calibration resistance to exact value found in Step 4, insulate spool as required and make sure all connections are tight.

(7) To check calibration, connect extension leads to rear of recorder and apply millivolt value determined in Step 1 across shunt ends of extension leads. The recorder pen should deflect to full scale if resistances are correct. Connect extension leads to MV terminals on shunt and proceed with recorder installation.

c. Voltage Method:

(1) Put instrument in operating condition and connect shunt extension leads to rear of recorder. Make sure all connections are clean and tight.

(2) Disconnect extension leads from shunt and apply a millivoltage across shunt ends of leads to produce precise full-scale deflection. Record this value; which should be somewhere above 500 MV (or above 250MV for center-zero ranges).

(3) Calculate millivolt value required at shunt terminals to produce full-scale calibration.

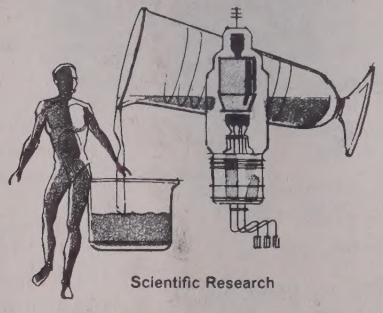
(4) The difference between Steps 2 and 3 is the millivolt value which must be compensated for by removing resistance wire from the calibration spool. Each lineal inch of resistance wire will represent approximately 4MV; and each loop inch about 8MV (or, 1/2 these values for center-zero ranges).

(5) Trim calibration spool by unwinding loop end of resistance wire, cutting out desired length, and soldering ends together.

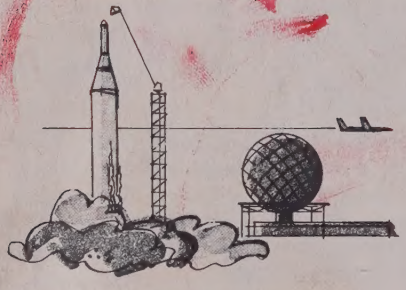
(6) See that millivolt value calculated in Step 3 produces full-scale deflection. Insulate spool as required and make sure all connections are tight. Connect extension leads to MV terminals on shunt and proceed with recorder installation.

Esterline Angus manufactures one of the most complete lines of scientific and industrial recording instruments in the world. Over the past 70 years, Esterline Angus has expanded its instrumentation to include:

GRAPHIC RECORDERS	• Galvanometric	• Electrodynamometer	• Event Recorders	• Pressure Recorders
	• SPEEDServo®	• Multipoint	• X-Y Recorders	• Vacuum Recorders
	• Potentiometric	• Oscillographic	• Minigraph	• Customized Units
TRANSDUCER DEVICES	• Signal-Conditioning Amplifiers	• Attenuators	• Industrial Tach Generators	
	• Potential Transformers	• Integrators	• Current Transformers	
	• Rotation-to-Pulse Transducers	• Multipliers	• Calibrated Shunts	
OTHER INSTRUMENTS	• Programmable Data Acquisition Systems	• Digital Printers	• Electronic Alarms	
	• Digital Multimeters	• Voltage Standards	• Function Generators	
		• Chart Inspectors	• Ultrasonic Cleaners	

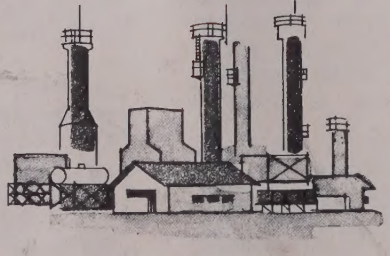


Scientific Research



Space Exploration

Production Analysis



Process Monitoring

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